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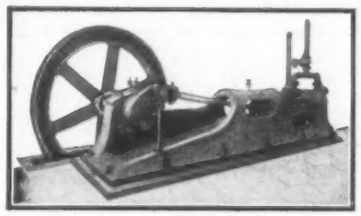

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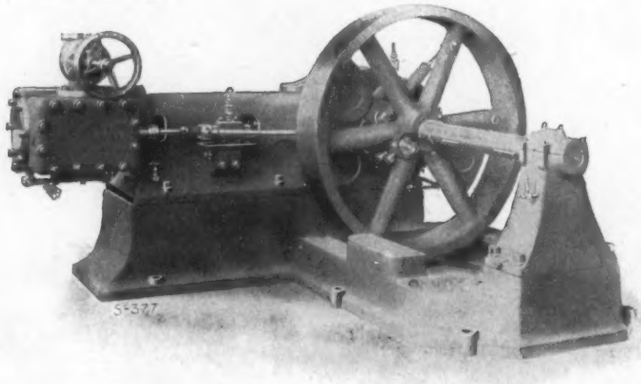

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VOLUME XV. SAN FRANCISCO, CAL., AUGUST, 1905. NUMBER 8

The System of the Portland General Electric Company.

BY F. G. SYKES—With introductory comments by the editor.

WHEN the Pacific Coast Steamship Company's steamer "State of California" arrived in Portland on her maiden voyage in the summer of 1879, it gave to Portlanders their first view of an electric arc lamp, for, bolted by a framework to the underside of the deck which formed the ceiling of its engine room, it carried a small one-light Brush arc dynamo that was driven by a small simple engine of a vertical type placed immediately beneath it. The single arc lamp which it operated was used in lighting the main saloon of the steamer, and so great was the interest evidenced in this then-marvelous light that the steamer was thronged by hundreds if not thousands. Then to further satisfy public curiosity on the succeeding trip, a

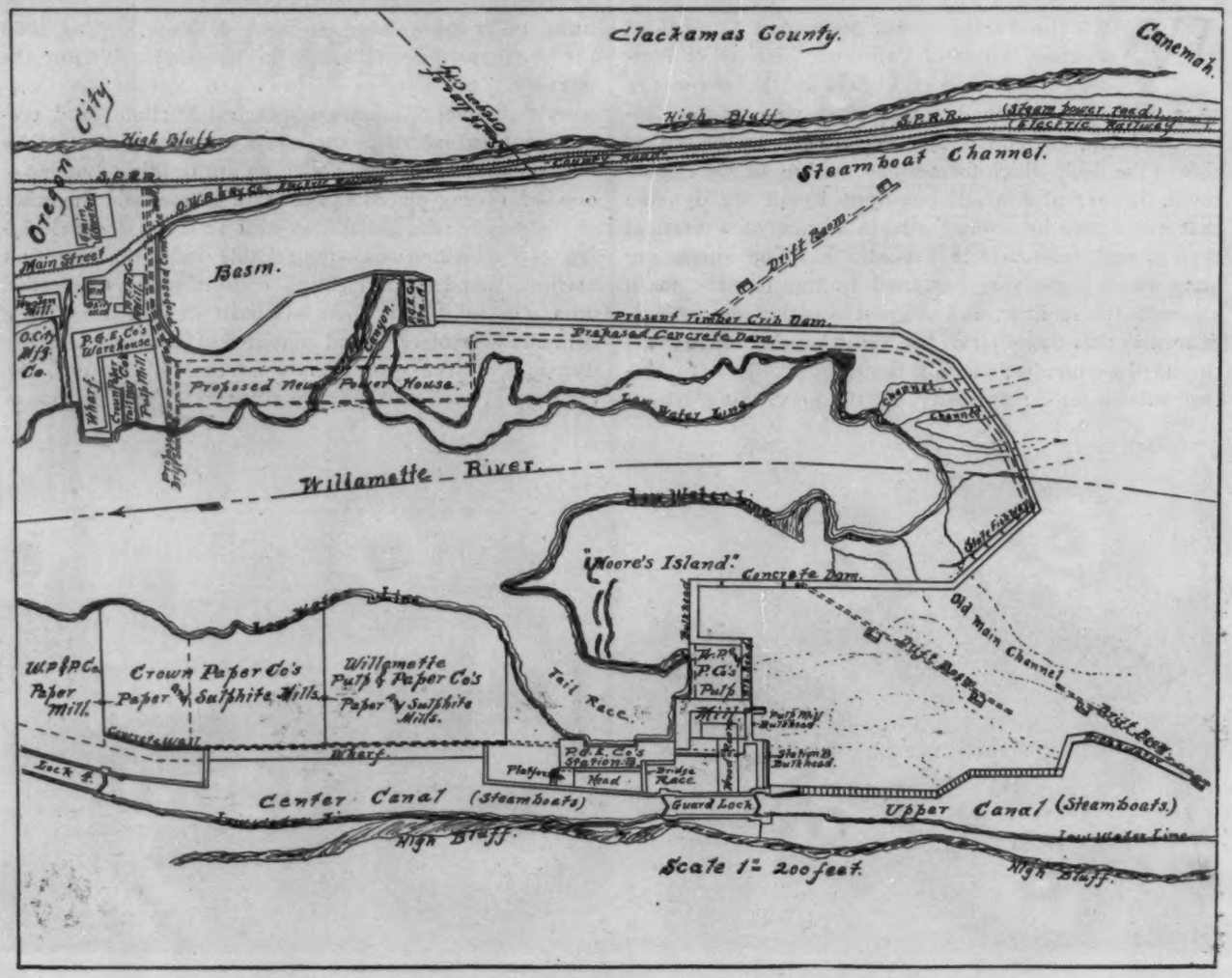
THE FALLS OF THE WILLAMETTE, AT OREGON CITY, OR.

circuit of bare copper wire was run over Flanders' Dock to the intersection of First and F streets—now Flanders Street—where in front of the old Clarendon Hotel the Brush lamp from the main saloon o the steamer was suspended for three nights in exhibition of its remarkable abilities as a means of out-of-doors illumination.

Thenceforth the electric lighting development of Portland was at first slow, but, nevertheless, steady. During the ensuing year a small arc dynamo, also of the Brush type, was installed in Weidler's saw mill, then constituting the extreme northerly limit of the city. Two or three lamps therefrom were placed about the mill yards, and a single circuit of bare copper wire was run up town to the corner of First and Oak streets, where a lamp was hung under the awning in front of Matt Keith's, then the best known oyster house in Portland. Within the next year the Oregon Railway and Navigation Company's steamer "Columbia" reached Portland and created renewed interst in the infant art of illumination by being equipped, not only with an arc lighting dynamo—one lamp being placed in the main saloon, and the other in the engine room—but also with an incandescent lighting plant, which was remarkable in being the first marine incandescent lighting equipment ever installed on any vessel. This plant has been described in these columns heretofore*—and consisted of four long-field core dynamos of the type known as the "Z" pattern, the capacity of each of which was sixty sixteen-candle-power lamps, but as only three of these dynamos were used for lighting service, the fourth being utilized as an exciter for the remaining three, the total output of the plant was 180 lights. Through this historic installation Portland saw its first indandescent electric lamps. Shortly thereafter two other incandescent lighting dynamos of similar make and capacity and one ten-light, 2000-candle-power, twenty-ampere Weston arc lighting dynamo were installed in Ainsworth Dock, this plant being operated by high speed steam engines, William H. Meeker being the engineer and electrician. This was Portland's first combined arc and incandescent lighting station; its service was confined to Ainsworth Dock, but it is possibly

*THE JOURNAL, Volume I, page 22, July, 1895.

worthy of note that at that time an amateur telegraph line extended through a dozen different stations from the corner of Fourth and Montgomery streets down to Ainsworth Dock, embracing a line length of perhaps four miles, and that over a portion of this line to a room occupied by the writer on the northwest corner of Front and Salmon streets, current for the operation of an eight-candle power Edison Incandescent lamp was transmitted from the Edison machines at Ainsworth Dock. This plant, which occupied the four stories, basement and sub-basement of a small ell on a rear corner of the Starr Building. The heavy pumping machinery was placed in the sub-basement below the river level, the boilers occupied the basement, the engines the first floor, and the dynamos the second floor. This plant continued in operation until 1886, when the machines were moved to Weidler' Mill as a part of the electric plant of the United States Electric Lighting Company, organized in 1885 to



MAP SHOWING THE POWER DEVELOPMENT OF THE FALLS OF THE WILLAMETTE RIVER, AT OREGON CITY, OR.

was undoubtedly the first instance of the use of the incandescent electric lamp operated from an electric lighting plant in a residence of Portland.

As an outgrowth of the installation at Weidler's Mill, which was instituted in 1882, the central station idea originated. Shortly prior to that time the Portland Hydraulic Elevator Works, owned principally by the Ainsworth estate, and of which P. F. Morey was superintendent, had erected a large steam-driven, high-pressure pumping plant on the river side at the foot of Ash Street, and in this pumping plant there were installed three, 20-light, United States arc dynamos, each driven by an independent Westinghouse high-speed engine. Commercial arc lighting service was delivered from this operate under the Weidler franchise. Geo. W. Weilder, J. C. Ainsworth and Mr. Morey were the prime movers in this undertaking. On March 18, 1885, the first contract for city lighting was taken, and at Weidler's Mill a brick building was erected for central station purposes in which the engines were placed over the boilers, the dynamos occupying the second floor. In 1887 this plant was enlarged by the addition of five 750-light, 1000-volt, Westinghouse alternators with Westinghouse engines to accompany them. This plant constituted the first alternating equipment of Portland, and it is noteworthy further in that it was sold to the United States Electric Lighting Company by H. W. Goode, then representing the Westinghouse Electric Company, and as such marks

his entry into the electric lighting business of Portland. The Weidler plant was operated about five years, during which time it was increased by the installation of four sixty-five-light Brush arc dynamos, and two Thomson-Houston fifty lighters. In the meantime the Weston arc dynamos had been impressed into service for incandescent street lighting, five 110-volt incandescent lamps being placed in series across the 550-volt circuit. Upon the advent of the Westinghouse machines, however, this primitive installation was abandoned for the then more modern series system consisting of fifty-volt lamps each shunted by a reactance coil. In the Weston series incandescent system each lamp was supplemented by a second one which was cut into service on the burning out of the first lamp.

THE ORIGINAL, OR 1893-'94, SECTION OF STATION B, AT OREGON CITY, OR.

By this time the possibilities of electricity for lighting purposes had become firmly impressed upon Mr. Morey, who from the outset believed in the eventual practicability of developing electrical power from the falls of the Willamette River, at Oregon City, and transmitting it for industrial uses to Portland, and these ideas culminated on November 8, 1888, by the incorporation of the Willamette Falls Electric Company, which was organized for the water power development stated. Station A was then built at the Basin on the east side of the river at the Falls, and into it were moved all the equipment that had been in operation at Weidler's Mill, with the exception of the original five Westinghouse alternators. Early in 1890 six 4000-volt, 1500-light, Westinghouse alternators were installed therein after seemingly endless difficulty in inducing the Westinghouse Electric Company to build generators of such an "excessively" high protential. These machines were the first ones produced from the Westinghouse shops having coil-wound armatures, all previous armatures being provided with the so called pan-cake windings. As the outgrowth of the Willamette Falls Electric Company, the organization of the Portland General Electric Company was effected in August, 1892, and in October of the same year Mr. Goode become identified with it as general manager, being elected to the first vice-presidency in 1900, and to the presidency in the spring of 1902. Mr. Morey, on account of ill-health, retired from business early in 1902, and died early in July, 1904.

The actual development of water power from the Falls of the Willamette dates from 1854 when Dr. John McLaughlin, agent of the Hudson Bay Company, erected a grist mill on Abernathy's Island, now about the site of Station A. This was followed in 1863-64 by the erection of the La Rocque Grist Mill on the site now occupied by the Portland Flouring Mills, which, indeed, was built at the outgrowth of the La Rocque Mills. Prior to

this, however, and in order to facillitate the landing of steamboats of the upper river of Oregon City, the people's Transportation Company had built the Basin, which was used not only as a steamboat landing but as a canal and forebay. Up to the time of the building of the Basin, freight from the upper river for Oregon City was landed at Canemah and transported thence to Oregon City by a mule tramway built in 1860 by D. P. Thompson, one of the pioneers of Portland. The Oregon City Woolen Mills were built in 1865 and in the early '70s the People's Transportation Company, appreciating the necessity for open navigation between the upper and lower rivers, began the construction of the Willamette locks, which were completed on January 1, 1875, the first river steamer to traverse them being the "Maria Wilkins." From the People's Transportation Company the ownership of the locks passed successively through the Oregon Steam Navigation Company, the Oregon Railway and Navigation Company, the Willamette Transportation and Locks Company and the Portland General Electric Company—the latter concern consisting of the consolidation of the Willamette Transportation and Lock Company and the Willamette Falls Electric Company. This ownership carries with it that of the entire water rights of the falls.

These locks are of interest not only from the fact that they are indespensible to river navigation, but also because of the further fact that many of the manufacturing enterprises there located are driven by water power taken from their canal. They are forty feet wide between the pitch lines, but being rock-faced will pass a steamer of a width of thirty-seven feet. The upper canal has a length of 1500 feet above the guard lock, after which follows the center canal having a length of about 1200 feet. Four lip locks are provided, each being 210 feet long, forty feet wide, and designed to give a ten-foot lift. The gates are timber-faced and the locks will pass during the low water season boats having a draught of three and one-half feet, with a seven-foot draught during high water and five feet being the average. It is of further interest to note that the amount of water consumed in the operation of the locks themselves is equivalent to the continual use of slightly less than ninety horsepower.

THE SECOND, OR 1896-'97, SECTION OF STATION B, AT OREGON CITY, OR.

According to the survey of United States engineers made in 1890, the Willamette River, at Oregon City, has a minimum flow of 15,000 cubic feet per second, but this rating is far in excess of the conservative figures which are relied upon by the hydraulic engineers of the Portland General Electric Company in the development of power. The latter figures, which are probably ultra

conservative, show that the maximum flow during the wet season is approximately 350,000 cubic feet per second, and that the average flow is probably one-sixth of that, with a minimum flow of from 6000 to 7000 cubic feet per second. These figures are from readings taken one-half a mile above the Falls. The head fluctuates from a maximum varying from forty to forty-two feet at the time of minimum flow to a minimum head of twenty feet at the time of maximum flow. In round figures these represent a capacity of 25,000 horsepower at minimum flow.

as it is possible for hydraulic power to satisfy the requirements. In the Willamette Mills, for instance, steam boilers to the extent of about 4000 horsepower are installed, and from them about 2500 horsepower in steam is used in making sulphite, the balance going to steam engines for operating the paper machines. In the Crown Mills about 900 horsepower in steam is used for cooking sulphite pulp and drying paper, while a steam engine of 100 horsepower capacity assists the water wheels. The new mills of the Willamette Company, and which are now under construction, will be driven by three 800

ANOTHER VIEW OF THE SECOND SECTION OF STATION B, WITH A PORTION OF THE ORIGINAL SECTION IN THE BACKGROUND

In point of reality the present hydraulic development at Oregon City is as follows:

Total east side development.....	5750 horsepower
Total west side development.....	26,850 horsepower
Total development.....	32,600 horsepower

The arrangement of these various properties are shown by the map given on page 300, which illustrates the contour of the Falls and the means that have been adopted for their present and prospective power development. All industries occupy not only the premises but their water rights as lessees of the Portland General Electric Company. The pulp and paper mills have been in operation on the sites indicated, since 1889, and they are operated exclusively by hydraulic power in-so-far horsepower electric motors in the beater mill, and it is the intention to gradually substitute electric power for water power in the paper mills as may be possible.

Probably the most difficult piece of construction work ever undertaken in the building of foundations on the Pacific Coast was encountered with those of Station B, which is located at a point that was beset with such difficulties in the way of securing foundations that no lessee could under any circumstance be induced to occupy the site. As the result the Portland General Electric Company was confronted with the alternative of occuping this site itself or leaving it vacant forever. It chose the former course, and the execution of its plan necessitated going to a depth of thirty-six feet below low water for bedrock. Station B is located on a site which originally

consisted in at least one-half its area in pot-holes filled with loose rock, to circumvent which the site was inclosed in a coffer dam that was three hundred feet long, twenty feet wide and forty-four feet high in its deepest part. This dam was of crib formation, sheathed with pine and filled with clay and gravel, and in pumping it out great difficulty was experienced from the wood-shavings which had accumulated there for years, clogging the foot valves of the pumps, which were of the centrifugal type, steam driven. No trouble was experienced after the mill refuse had been cleared away, and the dam was found to be perfectly stable. An idea of the extent of concrete work executed in Station B may be conveyed from the statement that above 20,000 barrels of Portland cement were used in its construction.

STATION E OF THE PORTLAND GENERAL ELECTRIC COMPANY, SHOWING TWO 1500-KILOWATT CURTIS STEAM TURBINES IN THE FOREGROUND

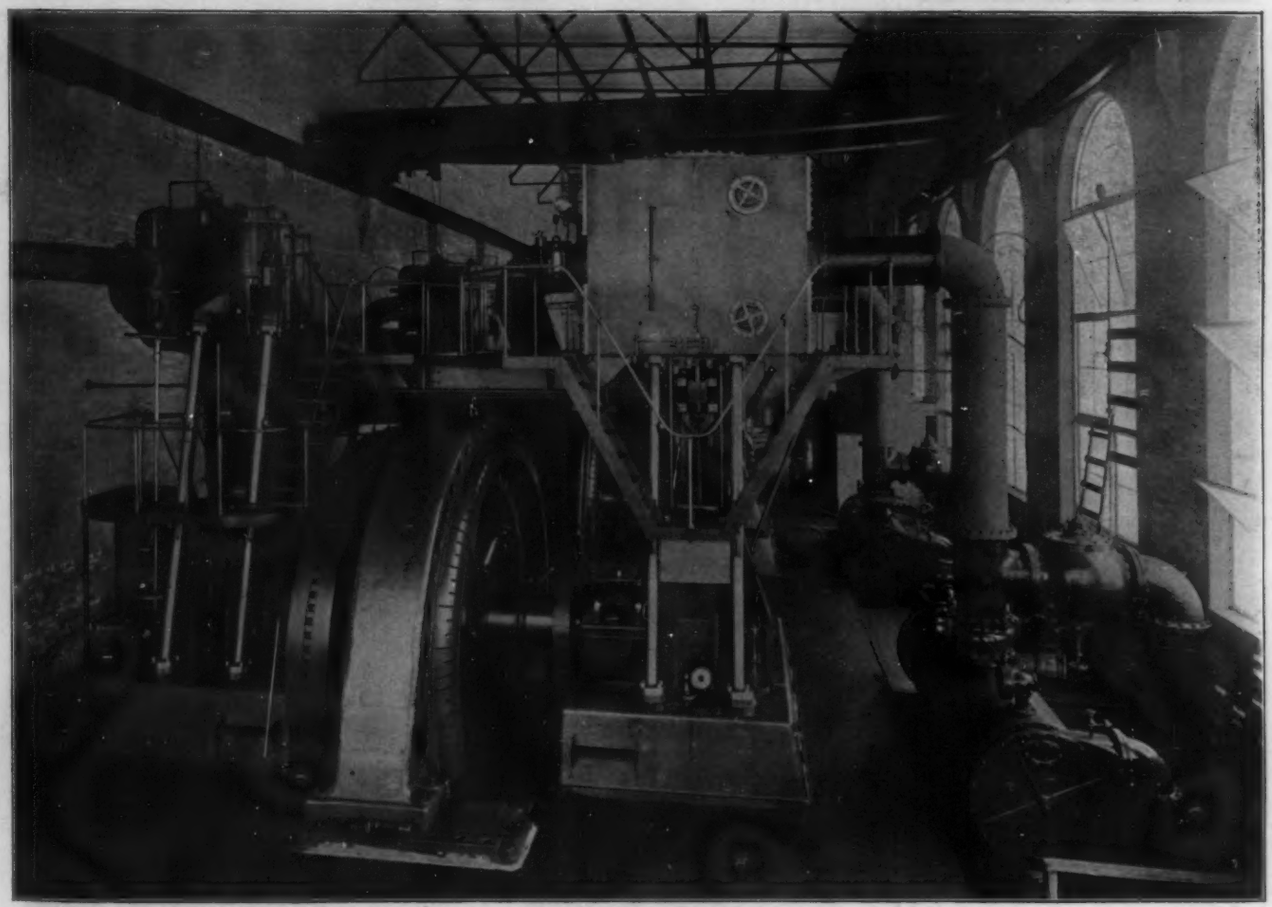
The physical conditions confronting the hydraulic design of an electric power house to be operated under a maximum head of nominally forty feet down to a minimum head of twenty feet will be promptly recognized as exceedingly severe, and those conditions were satisfied through the installation of two sets of water wheels to each generating unit, one set being twice the capacity of the other. Normally the smaller wheel, which is designed to operate under heads varying from thirty to forty feet, carries the load, but in times of high water in the lower river the larger wheel, which operates at heads varying from twenty to thirty feet, carries the load. These turbines are of the Victor type, regulated by Replogle governors. In addition to them Station B carries two McCormick turbines, each driving by direct connection through horizontal shafting a 550-kilowatt generator. These latter turbines are designed to carry full load under head of twenty feet, and they give their greatest efficiency during the period of low water. On the other hand they are never operated under a head of less than twenty feet.

The principal improvement contemplated in the way of the future development of power at Oregon City will consist in the substitution of a concrete dam for the present timber crib dam containing the Basin on the east side of the river. The course of this proposed dam is indicated by dotted lines on the accompanying map, and its southerly end will consist of a power house approximately 700 feet in length by about eighty feet in width, which will be equipped for the development of 40,000 horsepower in 3000-horsepower units.

It is the purpose of this article to discuss the principal historical and extraordinary features of the system under consideration, rather than to detail the apparatus which

its stations contain. In line with this policy it is pertinent to state that Station A is now abandoned as an electrical plant, all machinery being moved therefrom, but its wheels remaining for the operation of the East Side mill of the Willamette Pulp and Paper Company. Station B on the west side of the river is interesting mainly from the standpoints of its hydraulic features and types of generators. The two 250-kilowatt, 500-volt, direct-current dynamos of the vertical shaft type, while originally intended for use as exciters, are now delivering power for electric railway service; its three-phase generators are excited from direct current machines driven by belting from fly-wheels placed on the shafts of the McCormick turbines. Its newer three-phase generators deliver current at 10,000 volts in star connection, while the old 6000-volt generators have been rewound, and although some of them are at present delivering 6000 volts to line, the connections have all been changed over for the delivery of 10,000 volts. The station is operated under signal instruction from the substation at Portland, and it delivers power thereto only by the most simple and direct means.

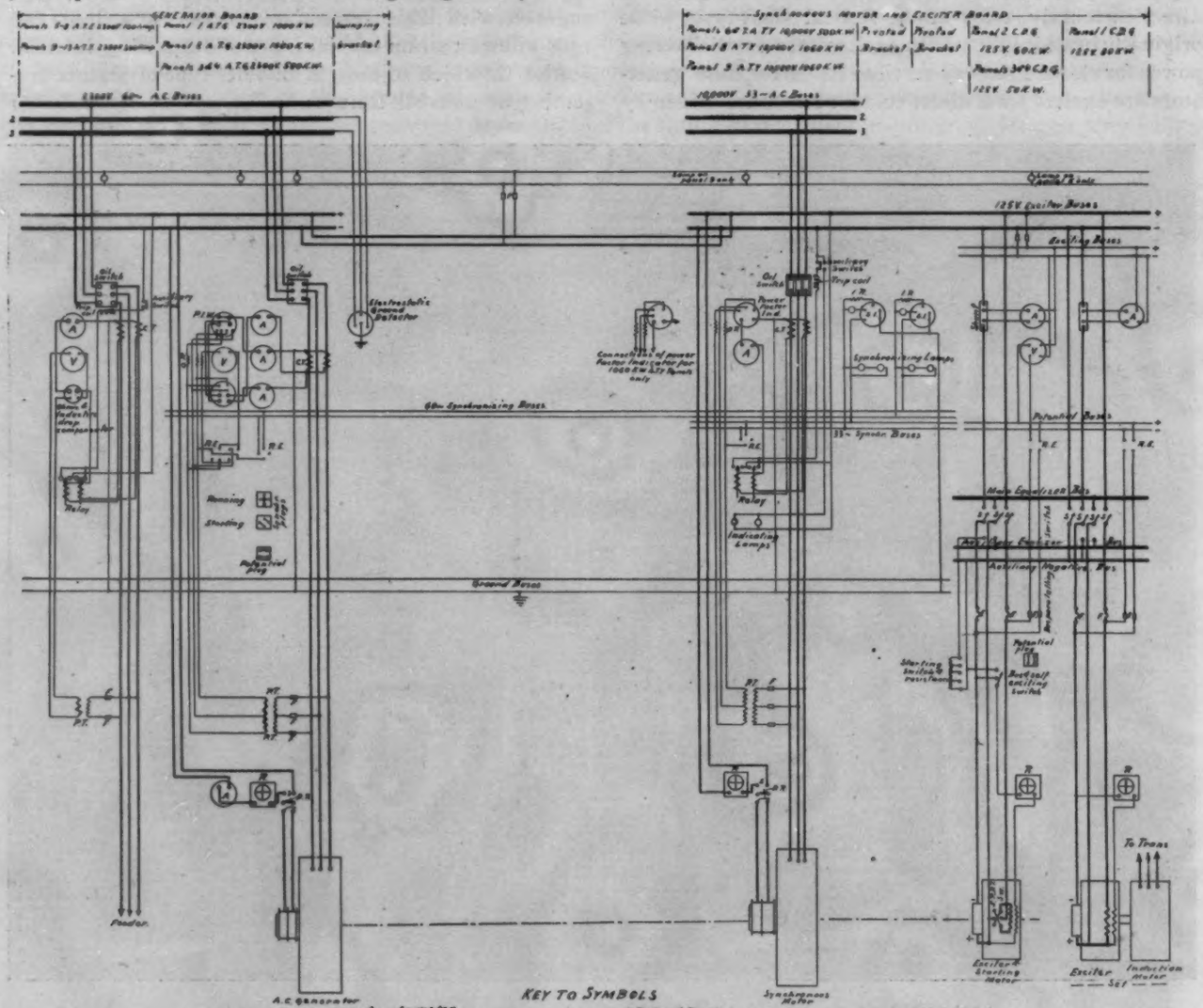
The additional generating plant of the company consists of two steam-driven stations located in North Portland, the equipment of which, together with that contained in the Oregon City plants, is listed in the table of engineering data which is appended hereto. Station E is a remarkable plant in many ways. The use of sawdust under conditions which exist enable it to produce power with an exceeding economy of fuel. Its concrete stack alone constitutes a remarkable engineering achievement. The station itself is of the best possible building construction and its generating equipment, consisting of two 1400-horsepower compound marine type engines, with their respective generators, and its two 1500-kilowatt steam turbines, are of surpassing interest. Station C, which adjoins, is an older type of station presenting no unusual features.



INTERIOR OF STATION E, PORTLAND, AS SEEN FROM THE END CONTAINING THE MARINE TYPE ENGINE UNITS

The bulk of the output of the various stations is delivered to Substation A, located on the northeast corner of Seventh and Alder Streets, adjoining the main offices of the company. The contents of this substation are also detailed in the table of engineering data, but particular interest therein centers in the three frequency-changing sets which it contains, one of them having a capacity of 1000 kilowatts and the others being rated at 500 kilowatts each. Locally these frequency changers are termed motor-generators, for they are of that type, consisting of a synchronous motor direct-coupled to a three-phase generator, the motor taking three-phase, thirty-three-cycle current at nominally 10,000 volts, and the generator delivering three-phase, sixty-cycle current at 2300 volts.

The use of thirty-three cycles dates from the time when Station B was built in 1893, and the selection of this frequency was adopted as a medium that would best fit the various conditions imposed by a mixed load, consisting of incandescent and arc lighting and power service, together with the operation of rotaries for railway duty. The subsequent determination of a periodicity of sixty cycles per second as standard in lighting and power



WIRING DIAGRAM OF THE 1000-KILOWATT FREQUENCY CHANGING SET

works made the installation of frequency changers a necessity, but the synchronizing of these frequency changers, considering their build, developed a problem the solution of which became a matter of exceeding nicety.

While it would be a simple matter to synchronize both sides under normal conditions in the design of machines built specially therefor, the fact that the ratio of the number of poles on the motor to those on the generator is as ten to eighteen involves serious complications. Overhung from the main bearing of each unit is a direct-current machine, provided for the dual use of starting motor and exciter, its potential being at 110 volts. The starting current for these machines is taken from the motor-generator set, consisting of a sixty-kilowatt, 220-volt, three-phase induction motor, taking current from a three-phase, 100-kilowatt, thirty-three-cycle transformer, the primaries of which are cut in on the 10,000-volt mains. This induction motor drives by direct connection a sixty-kilowatt, 110-volt, direct-current generator. The switchboard equipment consists of high-tension panels, equipped with hand-operated "K" switches that have automatic trips on the 10,000-volt side. Similar switches are installed on the generator side, but they are non-automatic. The motor board carries principally power factor indicators and ammeters. The direct-current panel carries five busses, as shown on the accompanying diagram, these being

the positive and negative exciter busses, the general arrangement being such that each machine may be started independently of the exciting busses, and so that these busses may give any starting combination without interfering with the exciter busses. Arrangements are further made for installing a Tirrell regulator on these busses should it be found desirable. In other respects the remaining panels of the board are of ordinary arrangements, with the exception of the synchroscope, which contains two dials, one for each frequency. In starting up the set a special switch that is provided on the overhung direct-current exciter is closed so as to convert it into a differential motor. The small sixty-kilowatt motor-generator set is then placed in operation, when, as soon as it has come up to speed the motor-starter, as the small direct-current machine on the shaft of the frequency changer is termed, is thrown on to the starting busses with suitable resistance inserted with its mains. This resistance is cut out as the speed rises, and when the machine is up to speed the fields of the synchronous motor are thrown under excitation, as are also those of the generator. The speed of the combined set is, of course, controlled by the rheostat of the starting motor, and in synchronizing it will be found that the needle of its motor synchroscope will make five revolutions to nine revolutions of the needle of the syncroscope connected to the generator. Synchronism is indicated when both needles reach the nodal points simultaneously.

The rotaries in this station are started inductively with fields open and with a very low applied voltage. Ordinarily the direct current brushes are arranged from the commutators and the rotary is brought up to speed with its generator at the steam plant, for each rotary has its own generator and circuit.

With these introductory observations the reader will become possessed of a better understanding of the general conditions existing in the system of the Portland General Electric Company, preparatory to the specific details which follows.—THE EDITOR.

AN INTERIOR VIEW OF SUBSTATION A, AT PORTLAND, SHOWING RESPECTIVELY TRANSFORMERS, ROTARY CONVERTERS AND FREQUENCY CHANGING SETS

GENERATING AND DISTRIBUTING SYSTEM OF THE PORTLAND GENERAL ELECTRIC COMPANY.*

BY F. G. SYKES.

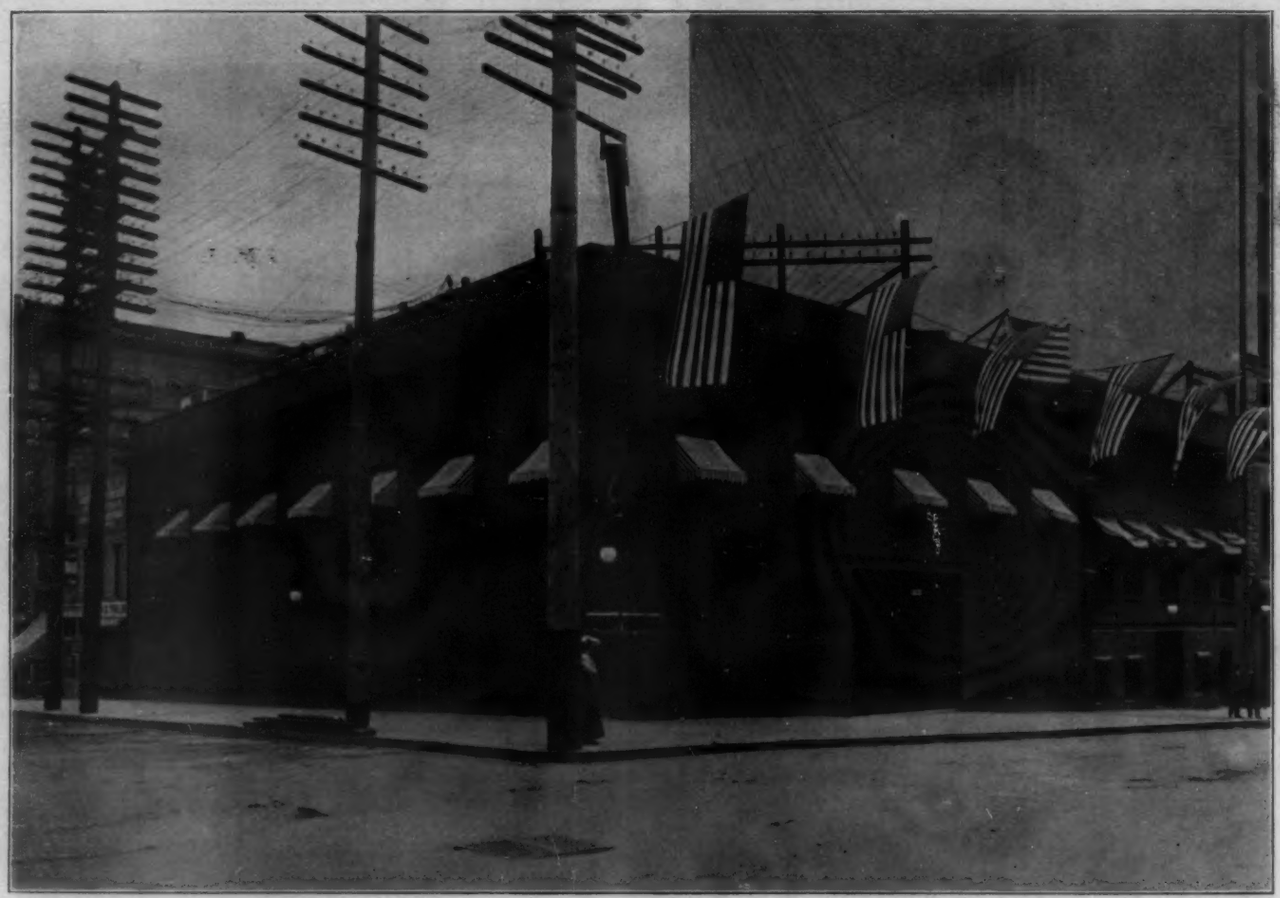
As it is probable that most of my listeners will find opportunity to visit the various stations and sub-stations of the Portland General Electric Company before the close of this congress, it is not the purpose here to enter into a lengthy description of the details of its stations, but rather to confine this paper to a general description of its generating and distributing system, leaving further investiga-

*A paper read before the Electrical Transmission Section of the Pacific Coast Engineering Congress, held at the "American Inn" under the auspices of the Lewis and Clark Centennial Exposition, Portland, Or., June 29-30, 1905.

tion to the individual members themselves, should they so desire.

The Portland General Electric Company's system is in some respects different from other similar systems, and it may be well to glance for a moment at the conditions which prompted the adoption of such a system.

About 1889, the Willamette Falls Electric Co. built a wooden station on the east side of the Willamette River at Oregon City, close by the Willamette Falls, and installed six Westinghouse eight-kilowatt 125-cycle 4000-volt, and two Thomson-Houston 120-kilowatt 125-cycle 2000-volt arc circuit generators, which were run by Victor turbines. The voltage of the Thomson-Houston machines was stepped up from 2000 to 4000 volts by means of transformers, and the power was transmitted to Portland on the east side of the river, while the power from the Westinghouse generators was transmitted at an initial potentian of 4000 volts to Portland on the west side of the river. In order to furnish this power at Portland, a distance of fifteen miles, to be used for incandescent lighting, eight single-phase circuits were run, or one circuit for each generator, one of these circuits being on the east side of the Willamette River and seven on the west side. Eleven 100-lamp 2000 candle power, Excelsior arc machines were also installed in the station at Oregon City, and three arc circuits were completed between Portland and Oregon City on the east side and eight on the west side, a circuit being provided for each arc machine. Sub-stations were provided in Portland, both on the east and west sides of the Willamette River, to accommodate transformers for reducing the received voltage from 3000 to 1000, which was the voltage used for distribution in Portland on the west side, and from 3000 to 2000 volts for distribution on the east side of the Willamette. I believe that this system inaugurated the first long distance transmission in this country, and that the Westinghouse generators were the highest voltage machines that had been built at that time.



SUBSTATION A AND GENERAL OFFICES OF THE PORTLAND GENERAL ELECTRIC COMPANY, AT PORTLAND, OR.

In 1894 the electric railway system in Portland was built, and it was necessary to furnish power for its operation. Four sections of the present Station B were built on the west side of the Willamette Falls at Oregon City and two 400-kilowatt rotary converters were located in the basement under the present office, at Seventh and Alder streets, Portland. In order to obtain three-phase circuits to operate the rotary converters and more copper to take care of the increased load, the arc machines were brought to Portland, direct connected to motors and arranged to operate at 500 volts, direct current, from the rotary converters. The arc circuits between Oregon City and Portland were arranged in groups of three wires

(Continued on page 372.)

The Pacific Coast Gas Association.

Being the Complete List of Papers Presented Before Its Thirteenth Annual Meeting July 18, 19, 20, 1905.

THE PRESIDENT'S ADDRESS.

It is with pleasure the writer greets you, gentlemen of the Pacific Coast Gas Association, upon the occasion of our annual gathering, the much-looked-forward-to, and pleasurably anticipated feature of Association work. A year has passed since we have had an opportunity of grasping hands in fraternal fellowship and friendship, a year replete with its accustomed joys and sorrows, hope and despair, successes and failures, but, withal, a year which, as gas men we can safely say passes into history with much to the credit side of our account, for the year has, indeed, been unsurpassed in the development of the industry which we represent, not alone in mechanical and financial successes, but also in the better understanding and closer relationship which exists between our customers and ourselves, a relationship which will grow closer and more steadfast as time progresses.

As gas men we are taught that notwithstanding the petty differences which may—nay, must—arise during our daily life, our trials and tribulations, our business impulses, greed and jealousies, notwithstanding the fact that even in business self-preservation is the first law of nature—all of these must be forgotten and forgiven as we convene for mutual intercourse, help to one another and benefit to the worthy and respected industry in the fields of which we labor, bearing in mind that the world is a mirror which returns only the smile or the frown which you give it, and that the world will laugh with you if you will only smile on.

In gleaming over the gas history of the past year one finds no startling event which so prominently stands forth as to eclipse all others. No revolutionary intention has been made, no great thought has been announced, no one individual has so risen to the high pinnacle of prominence as to eclipse all others. No revolutionary invention has tions have been consummated; but, lacking these, there has nevertheless been a wonderful advance due to a more general recognition and acceptance of the many merits of gas, so persistently advocated by the earnest worker in the cause, provided, as he is, by the capitalist, inventor and manufacturer with the means which enables him to command the business attention and respect of his fellowman, and more closely and prominently identify the gas business with the great commercial undertakings of the time.

While it may truthfully be said that the average gas man has been too conservative (a fault, by the way, not without its virtues) this charge can certainly not be laid to the doors of a host of the gas industries' representatives on the Pacific Coast, and for this reason is it that our Association has a world-wide reputation for originality, freedom of thought and expression, activity, progressiveness, vim, vigor and independence which excites the open admiration of our brethren of the elsewhere. May it be ever so.

To the credit of the Pacific Coast Gas Association be it said it has never been a close engineering organization narrowed, hampered and limited by technical thought alone. Rather has it been, as its name implies, an indiscriminating Association whose welcoming hand has ever been extended alike to the ultra gas man and his co-workers, the producer and manufacturer, whose advice and voice are unhampered and none the less welcome because of their tangent connection with the industry.

But all of the individuals of the Association cannot be said to be members of the gas profession, and in this strict sense it brings us to a consideration of the question of mere gas engineering, and there naturally arises the query: What constitutes a gas engineer?

For the writer's part, he must admit that, while claiming and using the title, he has always had a more or less dim and hazy idea of what should really be a gas engineer's qualifications; but, after years of thought and observation, he has concluded that a gas engineer must be a sort of conglomerate of all other engineering professions. His business brings him in direct contact with, and requires a versatile knowledge of, mechanical and civil engineering, chemistry, physics, architecture and nowadays, to a limited extent, electrical engineering as well.

Of late, the gas engineer, heretofore self-styled and self-sufficient, has been seeking a place in engineering channels, and demanding official and authoritative recognition, and more or less has been said and written on the subject, but no one has seemed to yet hit upon a satisfactory solution of the problem. It has been suggested that, as a profession, gas engineering be incorporated with mechanical engineering, the ultimate gas engineer being entitled to the M. E. degree, but this is a manifestly irrational solution, and cannot solve the problem.

The writer is of the opinion that educational institutions now qualified to confer the other engineering degrees mentioned, can easily and readily incorporate a gas engineering course by selecting from the others suitable studies and lectures, and, as a precedent to graduation, the condition that a certain and sufficient amount of practical knowledge be gained by the student through actual contact with the gas profession by specified employment with some qualified gas company.

This subject has already been given considerable thought and discussion by certain of the members of this Association, and about a year ago it seemed as

though preliminary steps would be taken to institute at least a course of gas engineering lectures in one of the leading educational institutions of the Pacific Coast, the lectures being voluntary efforts of several gas men. Unfortunately, the project did not quite reach the stage of materialization, but it should not be dropped, and your orator most earnestly recommends some action thereon by the Association.

There are, in the vicinity of San Francisco, two great institutions—the University of California, at Berkeley, and the Stanford University, at Palo Alto, both of which are well qualified to institute a gas engineering course with, possibly, the assistance of the Pacific Coast Gas Association, and individual members thereof.

While dealing with questions of education, enlightenment and advancement, it may not be amiss to uncover the one dark page of the Association's history, though on the broad principle of letting the dead past bury its dead, it were possibly better to be silent. The writer elects, however, to assume the risk:

Many members will recall the very excellent address of our esteemed co-worker, Mr. Chas. F. Adams, of Portland, Or., during his presidential term, and the well-meant advice contained therein. The address was referred to the usual committee (of which the writer was a member) who, in reporting thereon, recommended that certain changes be made to conform to the wishes of the gas company who, at the moment, was the host of the Association and who had also previously extended many appreciated courtesies.

At the time stated the press was waging a relentless war on our host, and as certain of the good advice given by Mr. Adams in a most general way to gas companies at large might, if appearing in the printed proceedings of the Association, be taken and used as a weapon to injure those whose hospitality we were enjoying, it was deemed but courteous and considerate that the revision be made. Mr. Adams unhesitatingly acquiesced, and the change was attempted; but, unfortunately, it did not seem possible to so revise the address as to meet the views of our host without entirely destroying the effect of Mr. Adams' remarks.

Pending a settlement of what had then grown to be a controversy, the proceedings of the Association were published by the gas journal minus the presidential address, and subsequently so in our official records.

Time, the great leveler, has proved to the writer that an error was made, and grave injustice done President Adams, and it is earnestly recommended that the best possible restitution be now made by publishing the address and making official record thereof.

This incident, though most unfortunate and regrettable, has not been without its lesson to the Association, as it has taught the value and necessity of liberty, and we now hold our conventions in independent quarters. Freedom of rational speech is all-important—aye, the very life of institutions such as ours, and must be insured, else we die.

Probably no world topic is now given so much earnest thought as that of Socialism, and probably no subject is so little understood. Certain it is the writer does not know sufficient thereof to even briefly discuss it, even in a most casual way. Even staid journals that are a power in the localities in which they are published, discuss the subject in a manner which shows how little they know about it. Some innocently look upon it as a scheme to divide everything. As a matter of fact, modern scientific socialism is a thoroughly cold-blooded proposition anticipating the realization of its ends just because of man's indurated graspingness, and inveterate instinct for getting all he can.

Socialism is not alone opposed to capitalism. It is opposed to the insolence of mob violence as well as to the arrogance of organized interests. It is opposed to centralization, notwithstanding centralization is the tendency of all human systems. It is, therefore, opposed to corporations and, as gas interests are generally corporate, it behooves them to take cognizance of socialistic tendencies.

So far, the menace of Socialism to gas interests extends only to the question of municipal ownership, but even if only to this extent it calls for early study, earnest thought and active attention.

To this time but little headway has been made in the municipal ownership of gas plants on the Pacific Coast, and but little thought has been devoted thereto, though, in common with other localities, the tendency is increasing.

As a matter of fact, it makes but little difference to existing gas interests whether the works are privately or publicly owned, so long as the plants, if privately owned, are justly and honestly taken and paid for when acquired by the municipality, or whenever it seeks to enter the gas business. Unfortunately, however, justice and honesty are terms which have but a vague significance to the average politician and professional agitator if he is inclined to be troublesome, and certain it is that no gas works will be surrendered by its owners unless there be received therefor a proper return. The lowering of selling rates insures only temporary relief, and, as rates cannot be lowered forever, there being a natural and fixed limit, some other form of adjustment would seem necessary. So far, but two practical plans suggest themselves, one being the regulation of gas properties, whether public or private, by a State Commission, and the other a profit-sharing plan whereby the municipality receives a certain fixed ratio of the gross receipts. Whatever the ultimate solution, the question is of the hour, and should be given earnest thought.

The writer does not mean to infer that all socialistic tendencies must be regarded as a menace, for he fully recognizes the justice of many socialistic teachings, and believes also that the true and earnest Socialist is a student of conditions to the end that the great mass of the people may enjoy the life and the privileges with which a good God has invested them.

Unfortunately for the advancement of scientific Socialism, the petty politician, the professional agitator, the arrant hypocrite, the asinine egotist and a host of other blood-sucking vandals, have clothed and are clothing themselves in the garb of Socialism, and to that extent must the honest theorist suffer and be regarded in the light of a menace until the evil has been cast out. It is the enlightened Socialist with whom we must ultimately deal, and we would better begin to properly meet the situation as it advances.

It would be difficult to say just which branch of gas engineering is now being given most consideration. Gas-making methods always receive their full share of attention, though for the past year, and especially on the Pacific Coast, there has been practically nothing new therein.

High-pressure gas storage and distribution is receiving continually increasing attention and is meeting with much favor. Therein is much that is new to the manufacturer and purveyor of artificial gas, and he is only now beginning to learn the lessons which are old ones with the natural gas industry. It seems strange that it should have taken so many years for gas engineers to acknowledge and accept the successes which should long ago have received their attention and study, and the innate conservatism of gas men is probably responsible therefor.

At the last meeting of the American Gas Light Association, Mr. A. E. Spangenberg of Philadelphia, Pa., exploded a mild bomb-shell in gas engineering ranks by reading a paper which set forth an extensive list of experiments made for the purpose of simplifying and improving the gas meter. For years past we have been apt to regard the usual gas meter as such a simple, accurate and satisfactory device, that but little thought has been given to it; but, in the light of Mr. Spangenberg's experiments, this seems to have been a most unwarranted assumption. His tests were simple and went only to the extent of greatly increasing the gas-delivering capacity of the ordinary meter with but little change and slight legitimate increase in cost.

Practical tests of the Spangenberg idea are now being made on an extensive scale, and thinking an inspection of the improved meter would interest the members of the Association, the writer has secured the loan of samples through the kindness of John J. Griffin & Co. and Helme & McIlhenny, meter manufacturers, of Philadelphia, Pa. The manufacturers seem to look upon the improvements with favor, and conclude that the principal question in connection with the new form is "What effect will wear and condensation have upon registration?"

The samples received were turned over to Mr. E. C. Jones for inspection and test, and he has very kindly offered to explain them to the Association, and this will be done during the session.

The Pacific Coast has, for some time past, enjoyed the distinction of having produced and put into operation the largest single gas-making unit in the world—a crude-oil water-gas apparatus, having a capacity of upwards of 3,000,000 cubic feet daily, having last year been erected at the works of the California Gas and Electric Corporation at Oakland. Advanced as was this undertaking, this same progressive concern is now outdoing its previous efforts by erecting much larger gas-generating units, *i. e.*, having a daily rated capacity of 4,000,000 cubic feet, and in connection therewith are installing three gas engines each capable of delivering 5333 brake horsepower, or a total of 16,000 brake horsepower for the three units. This stupendous undertaking marks an epoch in gas engineering to the credit of the fraternity at large, and doubly so to the progressive gas men of the Pacific Coast. During its session the Association will have the pleasure of listening to a paper from Mr. John Martin, descriptive of these gas engines, the largest in the world, and the work they are to perform.

At one time, long agone, it seemed as though the gas engine would become a most important factor in gas engineering, but this seemingly rational conclusion time has proved to be an error. While the old name—gas engine—still clings, and perhaps always will, it is, by some, more properly referred to as an internal combustion motor. Such motors will always occupy the attention of gas men, but the great development thereof has passed from gas engineering, through mechanical engineering, and into the hands of gas engine experts who are slowly but surely developing a new profession.

The great future universal success of the gas engine is dependent on some form of cheap, though effective, power gas, all kinds of which are now being experimented with, and all forms of fuels are being tested, including coals, coke, charcoal, petroleum, oils, hydro-carbon residues, volatile hydro-carbons, wood, peat, hay, straw, leaves, rushes, reeds, moss, sawdust, shavings and dried sewage. All kinds of combustibles are economically usable in one manner or another, and the time is probably not far distant when an enormous amount of our power will be derived through the medium of the gas engine from fuels we now allow to go to waste.

The growth of our Association is gratifyingly large and indicates an ever-increasing interest in gas matters. The scope of our Association work is broad and covers every subject tangent to the gas business, excluding none. Geographically, we are so situated that we are compelled to be more or less independent and self-sufficient. The broad Pacific on the west, the rugged Rockies on the east, a frozen North and a Mexican South lock us in an embrace which practically excludes those of our profession who live beyond our confines, and compels us to develop within ourselves. Ours is the task of overcoming local obstacles, and strenuous, non-ceasing effort is the price of life and success.

As an association, we owe our best efforts to the gas industry and, in return, there is due us the support, moral, financial and otherwise, of all directly or indirectly connected or associated therewith.

As our members are generally aware, there is on foot in the East a project looking toward the organization of

a national gas association and, in connection therewith, some sort of a consolidation of all American gas associations.

Complying with a request from the projectors of the new enterprise, this Association, by its representative, has met the others in conference, which meeting will be duly reported upon. The writer is quite unfamiliar with the happenings of the conference, but believes the best interest of this Association to lie in an unhampered preservance of its individuality, though there may be some ground upon which we can meet and lend our support and friendship in a mutually beneficial manner and, if so, it should be given due consideration.

While the writer does not believe it really exists, in even a single instance, it would seem as though many members of the Association were indifferent to the efforts of its officers. It is no small amount of work to arrange a meeting and carry it to successful outcome, and to your chosen officials is due the active support and assistance of the members as individuals.

A perusal of the official records will show that a certain comparatively few members carry the chief burdens, though the work should be more evenly distributed. Many of those who attend the sessions are capable, and doubtless willing, to do their share, but a false feeling of modesty apparently prevails. This must be cast aside; get on your feet, raise your voice, be sure your efforts will be appreciated, and because you may not be especially invited so to do, do not imagine your assistance is not welcome, for quite the reverse is the fact.

In addition to suggestions set forth above, the writer desires to make certain recommendations which he feels will be for the best interests of the Association.

It is recommended that a change be made in the date of meeting. This matter has been frequently discussed, and it is believed a majority of the members favor a change to corresponding dates in the month of September. At our last meeting your officers were empowered to make such change as they deemed for the best interest of all, but being a warm advocate of a change, your president has not cared to take the initiative.

It is recommended that, in future, membership in the the Association, active or associate, be a condition precedent to a trade display in the Novelty Department.

It is recommended that, in the future, membership in constituted, be discontinued and, in lieu thereof, that a librarian be appointed, who, in connection with the Secretary of the Association, will have control of the library and its funds.

Mr. E. C. Jones is now acting in the capacity mentioned, has been doing all of the work, and the very successful condition of the library is due to his efforts.

It is recommended that a majority of the Board of Directors, meeting at any time, be constituted an election committee *ex-officio*, with power to elect applicants for membership. This will permit of taking in members during the entire year and notifying them of election prior to the annual meetings, which will insure increased attendance.

It is recommended that efforts be continued toward seeking a permanent home for the Association. In the past we have attempted to secure subscriptions sufficient to establish a headquarters, but with only partial success.

The writer suggests the beginning of a fund by annual voluntary subscription for the purpose of ultimately securing a permanent home. In common with other localities, there will undoubtedly some time come a proposition looking toward securing a home, or headquarters, for engineering societies of the Pacific Coast, and when the opportunity offers we should be in a position to avail ourselves thereof.

It is recommended that discussion be had on the advisability of printing and distributing to members prior to annual meetings, the papers to be presented thereat. There are good arguments for and against this procedure and the subject should be ventilated, and, as well, the advisability of publishing the discussions in other than our official volumes.

The shadow of death has this year darkened the portals of the Association and called from our midst two well-beloved and earnest co-workers. Oscar B. Weber, of New York City, one of our charter members, passed to the Unseen Association on September 16, 1904, followed, on December 5, 1904, by Axel Gutsch, of San Francisco.

The usual committee will be appointed to prepare a fitting memorial, and its recommendations will be duly observed; but, in the hour of our sorrow, let us not forget there is no cross so heavy, no misfortune so great, no trouble so grievous, but laughter and song will ease the hurt and lighten the load. Life has its tragedies, 'tis true; and yet, when Death takes those we hold most dear, or lesser ills befall, we still have much to live for, and the sun still shines.

The program arranged by your officers is an excellent, though lengthy one, and must needs be somewhat hurried to completely fit it to the few hours at our command. Full and free discussion is invited on the papers which have been generously prepared by willing writers; but, as our time is so limited, it is quite necessary that discussions should not wander from the immediate paper under consideration.

In conclusion, the writer wishes to thank the members for their kindly attention and to particularly express his appreciation to all who have loaned their unstinted and best efforts toward carrying to success the Thirteenth Annual Convention, which is now left in your hands.

UTILIZATION OF GAS ENGINES IN CONNECTION WITH LONG DISTANCE ELECTRIC TRANSMISSION.*

BY JNO. MARTIN.

The very rapid progress in the development of electrical machinery and appliances during the past ten years has invited the capitalist and engineer to instal and operate many hundred thousand horsepower, utilizing the waters of the various streams as a source for generating the current. The prime incentive for such development from the

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

investor's standpoint was the fact that the source of power was being constantly renewed by the laws of nature, and with the authentic records of precipitation as a guide the prudent engineer has recommended a great many plants to be constructed which have proved financially and commercially successful.

The most notable examples of this progress have been and are being developed in the State of California. A great many surprises of a practical nature have been encountered by the managers of these various water-power electric developments with particular reference to earning capacity, and more particularly with reference to the relation of "plant utility to plant capacity," commonly termed "load factor." The manager is constantly trying to find ways and means of utilizing the electric current during such times of the day or night when his present consumers do not require it. Numerous plans and devices have been utilized to further this end.

Within the past year, the problem was presented to the officers of the California Gas & Electric Corporation, who were desirous of furnishing all the electric current for the operation of the street railroads under the control of the United Railroads of San Francisco, and negotiations were commenced with the officers of the latter company with that end in view. It was very difficult for the railroad people at first to develop even a hope that such a condition of affairs could be made feasible. Here was a company with its thousands of horsepower developed at no point nearer than 140 miles from the proposed place of consumption, and while it is true that this company has many sources of supply and many avenues of delivery, yet there was an insurmountable barrier in the minds of the railroad people as to the advisability of purchasing current at any price if the convenience of its patrons was to be sacrificed in any way. As one of the officers of the railroad company remarked, "We certainly desire to save money in the operation of our property—within reason, but at the same time, we care more for the good will and satisfaction of our patrons, and if any interruption of service should occur on all your lines feeding into this city at one time we cannot expect our citizens to be patient while sitting in the cars for an hour and a half until you get up steam."

The railroads are operating their steam plant for this service, and the power company suggested the continuance of the operation of these steam plants and receive a portion of the power from the power company, but this plan was not considered advisable.

After numerous interviews with an honest desire on both sides to try and accomplish the economic result, if it could be done without sacrificing the interests of the patrons of the railroad company, a firm conclusion was reached that in a service so large and important as the carrying of hundreds of thousands of people daily in a large city, nothing could be done on the plans outlined unless some absolute guarantee of continuity of service were available, and it certainly was not favorable from the standpoint of the utilization of steam engines for emergency purposes, because if steam were being maintained constantly under the boilers, no economy could result, and if the plants were allowed to cool off the time element of starting would prohibit their use.

The officers of the power company had been making thorough investigations of the development of the gas engine in large units, having sent two of their engineers throughout the entire East to make full and complete reports. In consequence, and as a last resort, the power company agreed to install three gas engine electric generating units, each unit having a capacity of 4000 kilo-watts, or a total initial capacity of 12,000 kilo-watts. This plant will be enlarged as rapidly as the requirements of the railroad may demand.

The guarantees which have been made by the manufacturers of these engines are particularly interesting, electric transmission in a position to practically guarantee continuous service, regardless of the length of its transmission lines or the momentary interruptions which do occur through causes beyond human control. It might be fairly stated that the gas engine stands alone as the only means of instantaneous generation of electric current at distributing centers in times of emergency, at any fair or reasonable cost.

The gas engine electric generating plant of the California Gas & Electric Corporation will also be utilized to a certain extent for the purpose of increasing the load factor of the transmission line, for it is obvious to those familiar with power transmission plants that after proper installations have been made, including full capacity at the hydraulic end, as well as in the power-house, and in pole lines, there is absolutely no increased cost for current to the power company, whether its load factor be .2 or .99, and any device which can be utilized to improve that load factor adds that much income and net profit for the power plant. In this particular case, the gas-engine generating plant was a necessity, for without which the California Gas & Electric Corporation would have been unable to have obtained the contract for power. That being the case, the officers decided to make a virtue out of this necessity, and up to the extent of the cost of fuel being less than the increased value derived from improving the load factor on the power lines, they propose to operate this gas engine plant in that manner and for that purpose.

The gas which will be used to drive these engines will be manufactured from crude oil, and will be of the quality similar to the illuminating gas now being distributed throughout the State of California manufactured by this process, ranging from 610 to 660 B. T. U. horsepower per cubic foot.

Nearly all of the gas engines in use throughout the East and Europe are utilizing producer gas or blast furnace gases, except in very small units or where natural gas can be obtained, and from investigations which I have made I have ascertained that the largest gas engine using manufactured gas of more than 600 B. T. U. horsepower has a rated capacity of 300 horsepower, while those in process of installation near San Francisco will, in each case, be more than seventeen times as large.

The nearest approach to these large engines in size are two which are in operation at Hastings, West Virginia, each having 4500 horsepower capacity, and driven by

natural gas, and being used for the compression of natural gas for transmission through a pipe line 200 miles in length. These engines have been and can be started from cold and rest to full load in less than sixty seconds.

The following is a description of these engines: These gas engines are now being built by the Snow Steam Pump Works of Buffalo, N. Y., and in general design and detail resemble very closely a modern high-grade massive American steampower engine. They are of the horizontal, twin tandem, double acting four-cycle type, giving two impulses to each crank per revolution. This is equivalent to a cross compound steam engine. Any cylinder head can be removed from any cylinder by simply disconnecting one jacket water supply pipe and removing the nuts holding the head to the cylinder.

All working parts are above the engine-room floor, nothing but water supply, gas, air inlet and exhaust pipes are below the floor, and these are arranged so that they can be trenched. All the main parts have their proper relative positions positively and permanently fixed by male and female centering fits of large diameter, thus practically insuring self-alignment.

Lubrication of the cylinders is effected by spreading. This is accomplished by leading four oil feeds, fed by individual oil pumps, to each cylinder, and entering the cylinder at points to successfully effect the proper spreading of the oil. The oil is fed to the cylinder on the inhalation stroke, and is spread on the compression stroke, thus being properly lubricated for the power or impulse stroke. The lubrication of journals is effected by means of a positive feed lubricator. Each oil feed is carried to the part to be lubricated by means of small tubing leading from a multiple feed oiler containing a small oil pump for each feed led therefrom. The feed to each part is positive and can be adjusted to give a fixed supply of oil per revolution of the engine. When the engine stops the oil feed stops, and when the engine starts the oil feed also starts. Inlet valves, mixers and cut-off valves will be designed so that gasoline can be injected to the surfaces necessary to be cleaned, rendering the dislodgment of any deposit an easy matter without removing the parts.

The pistons are carried by cross heads, thereby materially reducing the weight carried on the bore of the cylinders. By the use of three cross heads, the main, intermediate and outboard, proper alignment of the pistons is permissible after years of service, and it is questionable whether an engine without this feature can be regarded as entirely satisfactory.

The question of regulation in the generation of electric current by means of direct connected electrical generators has been a problem not only for the gas engine people but for the steam engine manufacturers to solve, and this has been done in the latter case within the past two years practically to the satisfaction of the electrical engineer, so that parallel operation is now successful. The builders of this engine are also following steam practice in this respect, and will be able to keep the angular variation within each revolution at a minimum, satisfactory to the electrical generator manufacturers.

The main shaft will be of the overhung crank type, having the cranks forged with the shaft and with crank pins forced into the cranks. The main connecting rods are simple, plain, with solid adjustable stub ends. The main cross heads are fitted with adjustable babbitted gibs and removable crucible steel wrist pins.

The pistons are designed in such a way that expansion of the faces can take place without affecting in any way the strength or life of the piston. Piston rods extend from the main cross heads clear through the cylinders to the outboard cross heads, and secured to same by nuts. Each cylinder is made in two parts, the joint being circumferential and located half way between the ends.

Separate supply pipes for each individual part to be water jacketed will be furnished, so that the amount of water fed to each part can be regulated, thus permitting the carrying of high temperatures in such parts as cylinder heads, medium temperatures in cylinder jackets, low temperatures to the rods, pistons and metallic packing.

These engines are started by the use of compressed air on storage in compression tanks. Safety devices are provided which carefully control the speed limit.

The dimensions of these engines are very interesting:

Length over all, 70 feet. Width over all of 34 feet.
Weight of heaviest casting, 60 tons.
Diameters of cylinders, 42 inches.
Length of stroke, 60 inches.
Main journals, 30 inches in diameter, 54 inches long.
Main cross head gibs, 27 inches wide, 54 inches long.
Diameter of center of shaft, 38 inches.
Weight of fly-wheel, 130,000 pounds.
Total weight of engine, fly-wheel and generator, 1,200,000 pounds.

These engines will probably be in operation on or before January 1, 1906, and from all the investigations which have been made by my co-workers, we are laboring under no doubt as to the absolute success of this installation when completed.

NOTES REGARDING GAS TARS.*

BY P. W. PRUTZMAN.

DEFINITION OF TAR.

The name "tar" is very generally given to a large number of products of decomposition of organic matter, its use being sometimes extended to cover almost any black and viscid liquid, whatever the origin. With more accuracy, it indicates a liquid produced by destructive distillation of organic matter; that is, distillation under such conditions as destroy the original substance, and produce from its elements new and different substances.

When solids of a complex nature, such as wood, coal, peat, lignite or bone are highly heated, the original substances are destroyed and the liquid or semi-liquid distillate is always, properly speaking, a tar. When complex organic liquids, such as petroleum and fatty oils, are heated, the liquid distilling over may be either a distillate proper or a tar, according to the temperature. For

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

instance, if we heat petroleum for some time to, say, 600° F., condensing the vapors, and then recombine the condensed portion with the residue, the mixture will be very nearly identical with the original substance. In this case the vaporized portion would be a simple distillate, being merely a portion of the original oil. If, on the other hand, we heated the petroleum to high redness, a mixture of the condensate with the residue would be entirely and radically different from the original oil, and in this case the condensed vapors would constitute a tar, though in appearance they might differ greatly from the tar of commerce.

From the standpoint of the gas-maker, however, only such tars are of importance as are produced in the retorting of coal, or in the partial gasification of petroleum. All destructive distillation, such as produces tar, also produces more or less permanent gas, and conversely, as is well known, all gas-making processes using coal or oil as raw material, produce more or less tar or its equivalent.

CLASSIFICATION OF TARS.

Commercial tars are divided, both chemically and practically (for commercial use depends necessarily on chemical constitution), into three distinct classes, viz:

Bone tars: from the carbonization of bones and animal refuse.

Wood tars: from the carbonization of wood of all kinds.

Gas tars: from the partial gasification of coal and petroleum.

With the first two classes we have nothing to do. Suffice it to say that they are completely dissimilar to the third class, both chemically and commercially. But tars of the third class, whether produced from coal or from petroleum, in retort, generator, blast furnace or coke oven, are essentially the same.

AS TO THE ESSENTIAL IDENTITY OF TARS.

The tars from different gas-making materials and apparatus vary so much in appearance and in commercial value that it is natural to think of them as differing chemically in like degree. Such is by no means the case. Gas tars are very complicated mixtures of substances having different appearances and properties. Different gas tars contain these substances in different proportions, but all gas tars contain most of the constituents of all other gas tars in some proportion and are therefore chemically speaking, very nearly identical. The great difference in commercial value rises from the fact that some of the constituents of tar are of considerable value, others of little or none, and, of course, tars containing high percentages of salable elements are of more value to the manufacturer than are such as are composed largely of unsalable substances.

The substantial identity of tars from different sources (hereafter in speaking of "tars" we refer solely to gas tars), and the reasons for the great variation in commercial value, may be seen on examination of the following analyses of typical samples. In these analyses only such classes are separated as determine the value: complete analyses of most tars have never been made, and would be too bulky for comparison if we had them.

ANALYSES OF VARIOUS TARS—TYPICAL SAMPLES.

Number	Source	Heat Used	Where Made	Date	Tar				Oil (e)				Free Carbon in Tar Per Cent	Specific Gravity of Tar
					Benzole Per Cent	Oil Per Cent	Pitch Per Cent	Grade of Pitch	Phenols Per Cent	Naphthalene Per Cent	Anthracene Per Cent	Neutral Liquid Portion Per Cent		
924	Coal..	Very Low....	Laboratory....	.....	? (a)	34.0 (b)	66.0	B	32.6	0.0	0.0	67.4(c)	Trace	0.950
317	Coal..	Low.....	Watsonville...	3/11/99	1.5	29.5	69.0	B	45.0	0.0	0.0	55.0	?	1.125
315	Coal..	Moderate ...	San Rafael....	2/17/99	1.5	21.0	77.5	C	19.0	8.3	1.7	71.0	10.2	1.189
1125	Coal..	Coke Oven...	N. E. G. & C..	1/ 4/00	0.0	41.0	59.0	B	11.0	17.1	4.2	67.7	18.3	1.174
305	Coal..	High	S. F. G. & E..	1/15/99	2.1	14.3	83.6	B/C	9.4	50.8	17.0	22.8	34.4	1.260
319	Oil ...	Low.....	Woodland.....	3/25/99	18.5(d)	25.7	55.8	C	Trace	0.0	0.0	90.0	11.9	1.115
1827	Oil ...	Moderate	Equitable.....	1/15/03	3.7	24.6	71.7	B/C	Trace	7.7	Trace	92.3	11.7	1.128
354	Oil ...	High	P. G. I. Co....	9/30/99	2.2	20.0	77.8	C	Trace	44.9	14.3	40.8	10.0	1.201
....	Oil ...	Very High...	Lowe Crude...	.....	0.0	6.0	....	....	None	10.0	?	?	94.0	Pasty

(a) Aliphatic hydro-carbons—no true benzole.
(b) Specific gravity 0.954.
(c) Specific gravity 0.882.
(d) Little, if any, true benzol.
(e) Figures are for crude products.

COAL TAR AND OIL TAR.

Coal tar is known to contain over two hundred substances, and the actual number is probably much larger, as of some of the less valuable portions almost nothing is known. It does not follow that all these substances would be found in any one sample, though it is more than likely that most of them would be. Other tars have been less studied, but it appears that oil tar (*i. e.*, water-gas tar) made at a fairly high temperature, closely resembles coal tar from the usual clay retort, except in the practical absence of phenols. As the temperature of carbonizing falls, the tars from coal become thinner, and richer in benzol and phenols. Below a cherry-red, however, the coal tars become contaminated with substances resembling some petroleum products, until at the lowest possible gasifying temperature coal tars closely resemble petroleum itself.

The tars from lignite are more closely related to petroleum than to coal tar: it will be remembered that in Scotland a considerable industry is based on the manufacture of kerosene and lubricating oils from bituminous shales, distilled in continuous retorts at low temperatures. The lignites of California give tars which can hardly be distinguished, chemically, from local petroleums.

Oil tars approach petroleum in constitution as the temperature of gasification decreases. Heavy petroleum cannot be distilled without the production of some gas; and, in the practical distillation of California petroleum, considerable quantities of gas, of fair illuminating properties, are found in the latter part of the run. So it will be seen that there is no definite line between gasification and simple distillation, and petroleum distillates shade insensibly into tars. Nevertheless, in spite of the lack of a sharp dividing line, the extremes of the scale are as perfectly distinct, both chemically and commercially, as the products of different materials could be. It is probably safe to say that a coal tar and an oil tar made at the same (high) temperature, would differ less than two coal tars or two oil tars produced at widely different heats.

The confusion between petroleum and the tars made from it in water-gas processes, is so widespread that it may be pertinent to point out a few of the numerous and important points at which the two materials differ.

Petroleum consists principally of what are known as "aliphatic" hydrocarbons. During gasification these almost entirely disappear, so far as liquid products are concerned, though they appear in quantity in the gas. gas. The liquid portions of the tar, however, consist almost entirely of so-called "aromatic" compounds, belonging to entirely different chemical series. The liquid products of petroleum all notably lighter than water. Most of the liquid products of tar are notably heavier than water.

Petroleum oils are very susceptible to decomposition by heat, and cannot be distilled without much alteration—oil-tar oils do not decompose in this manner, and may be redistilled repeatedly without change.

The solid portion of California petroleum (known as asphalt) is soluble in both petroleum and tar oil. The solid portion of oil tar (known as pitch) is completely insoluble in petroleum, but readily soluble in tar oil. The insolubility of pitch in petroleum is so complete that the addition of petroleum to oil tar, or to a solution of pitch in tar oil, separates the pitch in flakes or curdy masses.

Asphalt, from petroleum, is brownish or reddish-black and ruby-red in thin layers. Pitch, from coal or oil tar, is gray-black and opaque in the thinnest layers. Asphalt has no fluorescence in solution, pitch in solution has a strong green fluorescence. The lighter oils from petroleum all fluoresce blue; the light oils from either coal tar or oil tar fluoresce green.

Benzene, naphthalene and anthracene, which form a considerable part of the bulk of oil tar, are not found in the original oil. On the other hand the characteristic groups of petroleum are found in oil tar in traces only, being presumably carried through the generators unchanged.

In short, petroleum during gasification at high temperatures is completely destroyed, and the resulting tars belong, both physically and chemically, to the great coal tar group. Insistence on this point is justified, as the belief that petroleum tars are related to petroleum is, as stated, very widespread, and has caused many abortive attempts at manipulation along lines which the nature of the material rendered impracticable.

USES OF TAR IN THE CRUDE STATE.

Tars in the crude or semi-refined state are used for many purposes. Refined tars, in this sense, are such as have had the bulk of the water, and, in some cases, a portion of the free carbon, removed by means to be described later.

(1) As a solvent, or flux, the oils of tar being excellent solvents for a great number of substances. Tar is used in this manner principally for softening or liquifying pitch or asphalt of various kinds, being much better adapted to pitch than to asphaltic materials.

The reason for this is that tar consists of pitch dissolved in tar oils, and that while asphalt is readily soluble in tar oil, it is entirely insoluble in pitch, the latter being, further, from 50% to 80% of the volume of tar. A very light tar, consisting largely of oils, may be mixed with asphalt without precipitation taking place; but, if the tar be heavy and be used in quantity, either the pitch or the asphalt, or both, will be rejected and the mass take a pasty or granular consistency, devoid of strength.

When pitch and asphalt, neither in solution, are melted and mixed well, solution will sometimes apparently take place, but in most cases the mixture will separate in time, forming a stiff, pulpy, oily mass, entirely destitute of tenacity. On rare occasions a mixture of this sort will hold up, for reasons not understood.

(2) For making pitch without distillation. A mixture of suitable proportions of common rosin and clean, dry tar, heated to melt, and mixed, makes a very excellent solid pitch, though at a rather high cost.

(3) For saturating fibrous materials. Tarred or roofing felt, the most used material of this class, is a coarse, hard, wool felt saturated with hot tar, rolled and seasoned. The uses of this material are too well known to need comment.

The rationale of the seasoning process is rather obscure. Seasoning consists simply in allowing the rolls of saturated felt to stand for some months. As the rolls are very tight, and stacked solid, like cordwood, and as presence or absence of air currents appear to make no difference in the time required, the seasoning is probably not due to evaporation of the oils of the tar; it can hardly be due to any chemical combination of tar with the wool fibre. More likely, the viscous tar requires some time to penetrate the capillary tubes of the fibers. At any rate the felt, which is at first rather soft and a little

greasy, becomes perfectly dry, firm and hard, and is then much stronger than the dry felt, and almost waterproof.

Tarred strawboard and cloth are made to some extent for special uses, and tar is somewhat used for saturating stone or stoneware, for use with acids, to preserve stakes and posts from decay, and to render other porous materials waterproof. Brick boiled in tar, were once largely used for paving, with entire success, as even soft brick are rendered remarkably tough and lasting by this treatment, the cost of which has prevented its extension.

(4) As a stock for black paints and varnishes. Tar is combined for this purpose, with rosin or other cheap gums, rosin oil and drying oils, heavy tar oils, crude benzole, earthy minerals and ochres, etc. Of course, all mixtures of tar with any other material are black or nearly so.

Tar is freely miscible with tar oils and benzole; small amounts of turps or drying oils may be mixed with it; benzene, kerosene and other petroleum products are incompatible with tar. The best varnishes of this class are made from pitch or boiled tar, thinned with tar oils or benzole, and with a small quantity of one of the cheaper resins. These varnishes are glossy, dry with reasonable speed, and strongly resist chemicals and weather and, when properly made, are of considerable value.

Tar, alone, makes a very fair varnish, when of good quality, and when speed of drying is not essential. When a film of tar is exposed to air the benzenes and naphthalene evaporate out; the liquid heavy oils act, to some extent, as true drying oils, taking up oxygen from the air and forming a skin like linseed. Tar for this use must have but a small percentage of free carbon and, still more important, must not contain more than a trace of water. Much water in tar used for painting will cause it to streak, pit, and draw away from metal surfaces, and greatly reduce its durability.

(5) Tar has some use as a binder in briquette manufacture, and in the making of electrical carbons. Tar and pitch are excellent reducing agents for metallurgical purposes, especially pitch, because of freedom from sulfur and ash. The cost, of course, prevents any extended use for this purpose.

(6) Tar is used to some extent to preserve posts, floors and other wood from decay when buried. Its efficiency for this purpose is slight, unless the wood is first thoroughly air-dried or, better, kiln-dried and then boiled some time in the tar bath. Boiling ejects the water from the outer pores and allows the tar to penetrate deeply enough to be reasonably permanent. A mere surface coating, made by painting or dipping cold, has very little value.

The market value of a tar, for use in the crude state, depends to some extent on its freedom from free carbon and from ash, and to a much greater extent on its freedom from water, and on the ease with which the water may be separated. A tar, otherwise very poor, may be of value if free from water or if the water will separate on heating, but where heavy tars are so emulsified with a large amount of water as to require boiling for its removal, they are practically valueless. For many uses in the crude state the thickness or viscosity of tar regulates its value somewhat, and for such uses it is much more necessary that tar should be free from carbon than when it is to be distilled.

For most uses in the crude state no distinction can be made between coal tar and oil tar, but it may be said that, within limits, the lower the heat at which the tar is run, whether from coal or oil, the greater will be its suitability to such uses.

COARSE MANUFACTURED PRODUCTS.

Manufactures using tar as a raw material may be broadly divided into two classes: The manufacture of a few rough materials, made by simple distillation, etc., a business carried on at a great number of points and requiring but a modest investment; and the further working of these primary products into a great number of more valuable articles by complicated and expensive processes, this latter being a business of great magnitude, but requiring enormous plant and, therefore, confined to a few firms.

The coarse products of tar are, in general:

Benzole, or tar naphtha, of low grade.

Creosoting oil.

Reduced or, improperly so-called, "distilled" tar.

Pitch, of various grades.

The production of these articles is commonly combined with the saturation of roofing felt, the manufacture of black paints or varnishes, and often with various processes using asphalt, as in the production of building papers and prepared roofings.

The first process in the manufacture of almost all tar products is dehydration, raw tar containing from a trace up to 60% of water. Raw tar is commonly settled in tanks, the settling being often assisted by heating. The water of course rises, all tars being notably heavier than water. Very thick tars, and particularly such as contain much free carbon, settle very slowly even when kept near the boiling point of water, and occasional lots are met which are so completely emulsified as to resist all attempts to settle. Gentle stirring sometimes assists in breaking up emulsified tars, but usually such as resist continued heating are pumped to still, water and all, a proceeding which adds greatly to the difficulty of handling, as heavy tars are very prone to froth out of the still through condenser, and until the water is off, the distillation proceeds very slowly.

Stills used for tar are of the horizontal pattern, and usually of small size. There is an outlet to condenser, bottom drain for pitch, pump connections for filling, gauge and test-cocks, and one or two manholes for cleaning. The condenser is usually made in rectangular coils, of black pipe with malleable fittings, and immersed in a water-box. Arrangements are made for heating condensing water during the latter part of the run, to prevent freezing of condenser while naphthalene is running, and occasionally, condenser is threaded with a small steam

pipe for the same purpose. From condenser, connection is made into a small tank with bottom and top outlets, used in separating water from lighter oils. For heavy oils which contain no water, connections are made direct from condensers to running tanks.

Distillation is by direct heat only. Tar oils do not decompose during distillation, but distill as freely as water, so no steam is used in the stills as in petroleum distillation. Fractionation is usually rather crude, stillman being guided by the appearance of distillate, as to when it ceases to float, commences to crystallize, etc. Temperature of the still can be used as a guide only in part, unless nature of tar is exactly known, and gravity of distillate is even less reliable.

Still being filled to desired height, determined by experience and marked by a gauge, the fire is forced until temperature of tar rises to about 180° F. Fire is then lowered to prevent foaming, and a gentle heat maintained until the water is off. If the percent. of water is small, or if the tar is very fluid, only benzole will distil over with water, but if the tar is very heavy, or the water percentage high, much naphthalene will accompany latter part of water. The tar being finally dried in from one to forty-eight hours, the fire is again forced, and distillation of oil commences.

The first distillate after benzole will be of about the same weight as water. This "light oil" is the principal source of carbolic acid when coal tar is run, and is separated for that purpose, but the light oil from oil tar is small in quantity and is run to the creosote tank.

The light oil carries an increasing proportion of naphthalene as distillation progresses, and at from 350° to 380° F., will contain enough of this substance to freeze at normal temperature. After passing 420° the percentage of naphthalene in distillate commences to decrease, the oil becoming again fluid at about 520° F. Pitch remaining in still at this stage is of a soft-solid consistency.

Fluid oils now flow, becoming gradually more viscous, up to about 600° F., when crystals of crude anthracene begin to appear on cooling. At this stage the pitch in still is moderately hard. All the oil up to this stage goes into the creosote.

The percentage of anthracene and allied bodies now increases until the oil attains a buttery consistency on cooling—the pitch is now glass-hard (that is, of course, when cold). If pitch is the object of the distillation, the run is stopped at or before this stage. If run further, the pitch is gradually coked, the last oils being heavy and thick, and complete coking is reached only at a full red heat, the last distillate being a gummy wax. These last oils, obtained during the coking stage, contain some anthracene, but in a very impure state.

When anthracene is to be obtained, the oils are cut into a separate tank when second crystallizatton starts. This fraction of oil is cooled, and anthracene separated on filter press, to be further purified, but in this country this fraction is run, anthracene and all, into creosote.

Pitch remains as a residue in still. The yield of pitch varies greatly with quality of tar, but bears a definite relation to the possible yield of coke. The various degrees of hardness are:

Grade "A," glass-hard.

Grade "A-B," brittle.

Grade "B," flexible when hand-warm.

Grade "B-C," sticky when hand-warm.

Grade "C," sticky at normal temperatures.

This is Pacific Coast grading; a different system is used in the Eastern States.

Distillation being ended, pitch is drawn into a closed iron cooling box, as, if drawn into open kettles at a high temperature, it is likely to flash. When sufficiently cooled it is drawn into one-head barrels. In Europe, where most of the pitch is run very hard, it is drawn hot into cement or brick-lined tanks and when cool broken into lumps to be shipped in bulk. This is impossible except with the hardest grades, as softer pitches, even those which are brittle, flow under a slight pressure and soon coalesce to a solid mass. All American pitch is shipped in barrels.

Crude benzole is sometimes redistilled without treatment, to somewhat improve color, and to eliminate naphthalene always found in the crude naphtha. In this state it is used mostly by the tar refiner, though there is a small sale for various purposes. The manufacture of higher grades belongs to manufacture of tar chemicals.

The light oil fraction is also occasionally redistilled, for use as a paint thinner, and for making what are known as "creosote shingle stains." If the objectionable odor is removed by treatment with caustic soda before redistillation, it is very suitable for use with paints of moderate quality, as it is a much better substitute for turps than is petroleum benzene. Its use in this manner is unimportant.

At most American refineries all the balance of the oil goes to creosoting oil.

CREOSOTING OIL.

This material, less accurately termed creosote, heavy oil, or dead oil, is one of the most useful products of tar, though having but a single use, the preservation of structurad timber from decay and from the ravages of insects. The common name, creosote, applied to this article, is confusing, the true creosote of pharmacy being an entirely different material, the product of wood tar solely, and very closely resembling the phenols (e. g., carbolic acid).

Creosoting oil, as it usually comes to market, is a brown or black oil, 6% to 12% heavier than water, limpid when warm, partly crystalline when cold, and having a characteristic pungent odor. Its appearance and properties vary considerably with the specifications of the purchaser, but in general its manufacture involves merely the separation, from the mixture spoken of above, of part of the tar acids, naphthalene and anthracene. Usually the distillate is reserved in two or three fractions, containing different proportions of the different elements, and

these then blended according to the analysis of each, and the demands of the purchaser.

Creosote is used, in a general way, as follows: The timber to be treated is loaded on iron cars and run into a retort, a strong steel cylinder perhaps eight feet in diameter and forty to eighty feet long. The retort is provided with track and steam coils on bottom, with connections to a tubular condenser, pumps and drain tank, and with heavy cast-iron doors, swung on hinges and made up with swing bolts.

Retort being filled with timber, doors are locked up and warm oil run in above timber line. Steam, superheated or high pressure, is now turned into coils, until heat transmitted through oil commences to boil the sap, and this boiling is continued until only a specified quantity of water per hour, per cubic foot of timber, passes from condenser. The condenser is then shut off and pressure applied by pumping in oil up to, say, forty pounds per inch, pressure being kept on for from two to twelve hours, according to size and grain of sticks, amount to be injected per cubic foot, etc. The oil is then drained off and timber run out to cool.

The preliminary boiling exhausts the sap from outer cells of wood and leaves the pores open, and during pressing stage these open cells are filled with the oil. Lighter portions of the oil penetrate farthest, heavier portions forming a hard, dense coating on the outside of stick. The penetration across grain runs from one-half inch to three inches, and the amount used from two pounds to twenty pounds per cubic foot of timber, figuring the entire volume of stick. Ten pounds (about one gallon) per cubic foot is considered good work, and will give a visible penetration of say two inches across the grain, though in many cases some parts of the oil entirely penetrate the timber.

The strength of the stick is but slightly lowered by this treatment, when properly applied to selected timber. When green sticks are treated, there is some liklihood of checking, and when too great heat and pressure are used, incipient charring may set in with great reduction in strength.

Creosote contains tar acids, naphthalene, light hydrocarbons, and heavy neutral oils, sometimes some pitch. Opinions vary greatly as to the relative value of the elements, but the weight of opinion inclines to an oil with 5% of tar acids, less rather than more; 25% naphthalene, 25% residuum not distilling at 600° F., this residuum acting as an outer seal, the tar acids and naphthalene (and anthracene, if any) acting as antiseptics and insecticides, and the liquid neutral parts as solvents.

Creosote is insoluble in water and little affected by air. Recent tests made by the Southern Pacific Company at West Oakland, on piles which had been exposed to air and water for some years, show remarkably little deterioration in this time. The life of wood properly creosoted is at least trebled so far as rot is concerned, while this method offers the only known protection (except a complete coating of copper) against the ravages of teredo and limnoria. Petroleum and its products are unsuitable for this use, on account of their instability in air and water, and their lack of antiseptic and insecticidal properties.

For the manufacture of creosote, water-gas and other high-temperature oil, tars cannot be distinguished, either physically or chemically, from coal tar, except by the absence of tar acids.

MANUFACTURE OF SECONDARY PRODUCTS.

The number of coal tar products is so enormously large that only the briefest outline of their uses and methods of manufacture can be given, and they are, in the following remarks, grouped so far as possible into classes having the same general nature, etc., special attention being called only to such as are important or curious.

The following table shows the main classes of compounds, arranged according to the crude fraction of tar oil from which they are made:

First Runnings or Crude Benzole—

Benzene (C_6H_6) toluene, xylene, etc.
Nitrobenzene (C_6H_5NO), nitrotoluene, etc.
Aniline ($C_6H_5NH_2$), toluidine, etc.
Used as solvents, explosives, dyes, etc.
Paraffins and other aliphatic (petroleum) compounds.
Valueless, and contaminate the benzole products.

Carbolic Oil, or Heavy Oil.

Phenols (tar acids): Phenol (C_6H_5OH), cresols, etc.
Used in crude state as disinfectants.
Carbolic acid (phenol), cresol, etc.
Used in pure state as antiseptics.
Nitro compounds (*e. g.*, trinitrophenol-picric acid).
Dyes and explosives.
Basic compounds—Pyridines, quinolines, etc.
No commercial value.
Neutral Oils—Mixture of liquid aromatic hydrocarbons.
Valueless except as a part of creosote oil.
Naphthalene ($C_{10}H_8$).
A disinfectant.
Nitronaphthalenes and other compounds.
Used principally in manufacture of dyes.

Anthracene Oil—

Anthracene (C H), phenanthrene, etc.
Used in making dyes.
Anthracene oil, or "red oil."
Lubricants, timber preservatives, etc.
Paraffins (solid).
Valueless.

Pitch—Usually sold as such; locally the most valuable product of tar.

Free Carbon—Existing in a fine powder in the tar, and found in the pitch, any considerable quantity being very detrimental to the quality of the latter.

Ash—An impurity not found in tar to any great extent as a rule.

BENZOLE PRODUCTS.

In the manufacture of different grades of benzol, and the numerous secondary products, different factories have

different methods, many of them secret, and in the following description no attempt is made to give more than the bare outlines of working methods.

The crude benzole is redistilled, only a portion being taken off, and the residue being worked into light oil, carbolic oil or creosote. The distillate is agitated with sulfuric acid, mechanically or by air blast, the acid oxidizing and dissolving various tarry, resinous, basic and unsaturated impurities, and becoming black and thick. This process involves considerable fire risk, on account of the extremely inflammable nature of the material, and great precautions are taken. The oil, settled free from acid, is then washed repeatedly with water, then with caustic soda solution, the latter removing phenols and mineral acid, finally with water until neutral. The washed oil is now subjected to repeated distillation, or to rectification in a column still (such as is used for alcohol), and the various products separated by fractionation, regulation of still and condenser temperatures, etc. In working for chemically pure benzene, toluene, etc., both distillation and chemical treatment have to be repeated once or several times. The final products are:

Chemically pure benzene, toluene, xylenes (three), cumene, pseudocumene, mesitylene, durene, etc., used to a limited extent as chemical reagents.

Pure nitro-benzene, nitro-toluene, etc., also used as reagents, are made from pure benzene and toluene by method detailed below:

Mixtures of the above, sold as 40%, 50% or 90% benzol (the percentage refers to the reading in a set distillation test, not to the proportion of actual benzene) containing different proportions of the different elements, used as solvents and in the manufacture of nitro-benzene (commercial) and aniline.

The nomenclature of these light products is very confusing. The term "benzole" is applied to the unpurified first runnings, the word "benzol" commonly means a water-white naphtha prepared from benzole by treatment and redistillation, and consisting essentially of "benzene," the pure compound C_6H_6. The latter has again to be distinguished from "benzine," a mixture of paraffins produced from petroleum and entirely distinct from benzene.

In the same way, "aniline" is properly the amido compound of benzene, the corresponding compound from toluene being called "toluidine," etc., etc. In the trade, however, the term "aniline" refers to a varying mixture of aniline, toluidine, xylidines, etc.

The term "nitro-benzene" properly covers only the nitro-product of pure benzene, but the nitro-products from different grades of benzol, which should be, and sometimes are, termed "nitro-benzol," are more commonly known as "nitro-benzene."

Commercial nitro-benzene (properly, "nitro-benzol," commonly known in the drug trade as "oil of mirbane") is made from any grade of benzol by the action of a mixture of nitric and sulfuric acids. The acids are mixed gently with the oil, a little heat being used, the spent acids are withdrawn, and the nitrated oil neutralized with alkali (sometimes) and washed repeatedly with water. Nitro-benzol is the raw material for aniline, and is also used in explosives, and because of its powerful odor (resembling oil of bitter almonds) as a coarse perfume in soap manufacture, etc.

Commercial aniline is made from nitro-benzol by the action of iron turnings and acetic or other mild acid, the whole being mechanically mixed in an agitator provided with condenser. The reduced oil is distilled out of the mass, redistilled, and sometimes otherwise purified.

The term "aniline dye," as commonly used, refers to any coal tar dye, or, indeed, any dye not occurring in nature. Properly it means a dye made from aniline only.

The aniline dyes are produced from aniline by a great number of methods, some of them of extreme complication. To even describe the different shades produced from this material would require a volume.

The number of aniline dyes is so great that their manufacture forms a trade to itself, entirely distinct from the tar business. In fact, while tar is the prime material for almost all the dyes of commerce, the expense attending manufacture is so great that the cost of raw material is but an infinitesimal part of the value of finished product.

Benzols of various grades are extensively used as solvents in many industries. Benzol is a perfect solvent for sulfur, rubber, pitch and asphalt of all kinds, resins (but not the fossil gums), waxes, fats and oils, in fact its solvent powers are probably greater than those of any other substance at all approaching it in price. As it has a high resistance to chemicals, is unaffected by oxidation, evaporates rapidly and leaves (when pure) no odor, its use has grown almost as fast as the increase of production. A large proportion of the total output of benzol is used as a solvent, in one form or other, mostly in a water-white color, but in a wide range of boiling points for different uses.

PHENOLS, OR TAR ACIDS.

These bodies are found in coal tar only, oil tars yielding but a trace, and that not of workable quality. For the manufacture of phenols the light oil with the first part of the heavy oil is chilled and strained free from naphthalene. The strained oil is then treated with a moderately dilute solution of caustic soda, which dissolves the phenols and some naphthalene. The naphthalene separates on dilution of the alkaline solution, and is skimmed off: the clear, aqueous solution is then neutralized with some acid. This separates the phenols, which rise to the surface as a black oil, which is separated and settled free from water and salts.

Crude carbolic acid is put on the market in various grades, notably the following:

Thirty per cent.—Not separated chemically as above, but consisting merely of the richest portion of the distillate from tar still. As would be indicated by the name, about 30% of the volume of this oil consists of a mixture of phenols, the other 70% of neutral hydrocarbons (light oil).

Ninety-five per cent. black acid—the acids separated

by the chemical treatment above, without further manipulation.

Ninety-eight per cent.—A straw to rose-colored oil, produced by distilling the 95% acid.

The crude acids are used as disinfectants and also in the manufacture of sheep and cattle dips, tree sprays, etc., all of which are compounds of crude carbolic with various soluble soaps.

Pure acids are made by treating the redistilled acid with some oxidizing agent, commonly sulfuric acid or bichromate of potash. The treated oil is then repeatedly fractionated, as in the manufacture of benzene, the various acids being separated by their difference in boiling point. The manufacture of pure crystallized carbolic acid (absolute phenol) is quite a delicate process, but the higher liquid acids are simpler. The uses of these acids as antiseptics and disinfectants is well known: in appearance and properties all members of this group resemble each other closely.

Pure carbolic acid is the raw material for picric acid (trinitrophenol), made by a process similar to that used for nitro-benzol. Picric acid is a yellow, crystalline substance, soluble in water, used as a yellow dye for silk, and as a drug for the relief of superficial burns, for which purpose it is probably the most effective agent known. Its salts with ammonia, etc., are highly explosive, and are the basis of the "lydite" used by the British artillery, and of other nitro explosives.

NAPHTHALENE.

Crude naphthalene crystallizes from the oils, boiling between 350° and 500° F., in grayish-yellow, warty crystals. When oils containing naphthalene are suddenly cooled they completely solidify if the percentage of naphthalene is sufficiently high, in which case the mass breaks down, on crushing and stirring, to a granular semi-liquid pulp. If the solidified oil be allowed to stand quietly for some months, the naphthalene decreases in bulk, forming large flat or globular cells, filled with clear oil, the walls of these cells being of considerable hardness. Naphthalene allowed to thus agglomerate in a tank, and drained free from the accompanying oil, can be removed only by melting or by very energetic use of pick and bar, though when freshly cooled the mass could have been very readily reduced to pumping consistency by gentle stirring.

The first step in the purification of naphthalene is to remove the accompanying oil, the melted mass being cooled as rapidly as possible, stirred until smooth, drained on sacking or other porous material, and pressed in hydraulic presses or pumped into filter press. The press cakes in either case are grayish-yellow, quite hard, and contain from seventy-five per cent. to ninety per cent. pure naphthalene.

The press cakes are then melted, and treated with sulfuric acid, followed by alkali, in the usual manner, sometimes also with potassium bichromate or manganese dioxid. The treated naphthalene is then redistilled in a simple still without rectifying head. A little water and oil are collected, the bulk of the distillate being pure naphthalene. To obtain an article of the highest purity, the distilled naphthalene is sometimes sublimed, being heated for this purpose on shallow pans, to a temperature somewhat above the melting point, the vapors passing into chambers where they solidify to a crystalline crust, covered with the well-known white flakes so characteristic of this body.

Naphthalene is used as a disinfectant and insecticide, for the enrichment of gas in special forms of lamp (not used in America), and as the basis of nitro-naphthalenes, naphthols and phthalic acid (etc.), used principally in the manufacture of dyes.

Naphthalene for disinfecting purposes appears in the trade principally in the form familiarly known as "moth balls." In the drug trade it is known as "tar camphor." As a disinfectant it is very effective, though its pungent and offensive odor, which is characteristic of the pure substance and cannot be removed, is a drawback to its extensive use. In making moth balls and stick naphthalene, the distillate from restill is cast in moulds direct from condenser.

Naphthalene has never been successfully used for enriching gas in bulk, in spite of its very great illuminating value, because of its tendency to separate with change of temperature or pressure, a tendency all too well known to gas men, as well as from other causes. In Europe certain forms of lamp have been used in which stick naphthalene, in metal receptacles, is kept melted by the heat of a flat gas flame, the gas being passed through or over the melted naphthalene. While very poor gas may thus be enriched at small cost, the apparatus is, for the most obvious reasons, much too treacherous to ever come into general use, and probably could not compare in efficiency with modern forms of the incandescent gas light.

Nitro-naphthalene is made from pure naphthalene in exactly the same manner as nitro-benzol from benzol. There are several nitro compounds of which one (the mono-alpha) is used to some extent for deblooming mineral oil. The blue overtone of light petroleum products may be completely removed by dissolving nitro-naphthalene in the warmed oil, but as the color is depreciated and the cost rather high, other and less direct means to the same end are more widely used.

Naphthylamine, prepared from nitro-naphthalene as aniline is prepared from benzol, is used in the manufacture of dyes. Phthalic acid, and combinations of naphthalene with chlorin, etc., are used for the same purpose. A series of naphthols, bearing the same relation to naphthalene that phenol (carbolic acid) does to benzene, are also used for this purpose. Most of the naphthalene dyes are shades of red or yellow: they are among the cheapest of the coal-tar dyes, but as a rule brilliant and permanent.

The properties of naphthalene have been often described. At normal temperatures it is a hard, brittle, crystalline, white solid. It is readily soluble in the tar oils, phenols, petroleum products, alcohols, ethers, and in fact

most organic solvents, the fatty oils, etc. It is slightly soluble in water and alkaline solutions. When melted it is a ready solvent for sulfur, rubber, fats, waxes and resins, to all of which it imparts softness and a greasy consistency on cooling.

Naphthalene rapidly evaporates from solid masses, even at 30° F. Mixtures of its vapor with air are quite permanent when not disturbed, but on coming in contact with solid surfaces when in motion are very likely to separate. Warm air or other permanent gas dissolves a large quantity of the vapor, which separates again on cooling, or on increase of pressure.

On heating naphthalene it is readily sublimed at temperatures much below its boiling point. Even at the melting point it volatilizes with some rapidity, the vapors solidifying without passing through the liquid form. This vaporization and resolidification takes place so readily that if a bottle containing the crystallized substance be set in the sun, the shaded side of the bottle will in a few minutes be covered with sublimed flakes.

The best cheap solvent for naphthalene is, locally, the petroleum product known as "engine distillate." This material will take up a large proportion of naphthalene without heating, and with minimum danger of separation, though all strong solutions of naphthalene show a decided tendency to crystallize out. Naphthalene may, as is well known, be removed from inaccessible places by means of steam, though as the naphthalene condenses with the steam to a hard solid, the method is open to objection. A current of warm air, where it can be had, is slower but more satisfactory, as the air carries the naphthalene completely away instead of driving it forward to cooler parts of apparatus being cleaned.

Naphthalene is formed in the gasification of both coal and oil, the yield being greater as the temperature of gasification increases. For instance, the tar formed from oil at low red heat in the Pintsch retort contains much benzol (very impure) but little or no naphthalene. In the older forms of water-gas apparatus, which were run at a comparatively low temperature, less benzol and more naphthalene appeared in the tar, while the tar from high heat water-gas apparatus contains much naphthalene and little or no benzol. The explanation is, in brief, that just as olefins are formed from paraffins, acetylenes from olefins, and benzenes from acetylenes, by elimination of hydrogen followed by condensation, so benzene breaks down to ethlene and naphthalene at high temperatures:

$$(2\ C_6H_6 = C_1\ OH_8 + C_2H_4)$$

This reaction is rather an assumption, but it is certain that benzene is converted into naphthalene and other products at high heat. Phenals are also converted into naphthalene at strong redness, or on long continued heating above the boiling point of water.

These reactions proceed in one direction only, that is, one compound may be changed into another richer in carbon, but not into one richer in hydrogen; the process by which naphthalene is formed cannot, therefore, be reversed, and the naphthalene broken down into benzene or illuminants. And as the completest possible conversion of the paraffins and olefins of petroleum into fixed gases is essential to the efficiency of all oil-water gas processes, and further as naphthalene appears to be the ultimate product of this series of heat reactions, and incapable of conversion into liquid or gaseous substances, it is probable that there is no remedy for the "naphthalene trouble," unless it be in the line of mechanical improvement in the handling of gas after it leaves the generator.

The supply of naphthalene is far greater than the demand, and in the crude state it may be said to have no commercial value. Tar refiners work the largest possible amount into the creosoting oils, and great quantites are used for fuel.

ANTHRACENE.

Anthracene is separated from the heaviest and last portions of the distillate by redistillation (which crystallizes the buttery mass), pressing and subliming. Crude pressed anthracene contains but from 20 per cent. to 30 per cent. of its weight actual anthracene, and the removal of the impurities is a tedious and complicated process, which adds greatly to the cost of the finished product.

Anthracene is used solely in the manufacture of dyes, of which there are a considerable number, in shades of red, orange and blue.

On account of the active demand and the small yield, anthracene is in Europe one of the most valuable constituents of tar. Its use and manufacture in America are very restricted. Anthracene from oil tar appears to generally be badly contaminated with solid paraffins, and therefore not of the best quality.

The manufacture of lubricants from anthracene oil, which has been practiced to some extent on the Continent, would be out of the question in a petroleum-producing country, and calls for no comment.

Anthracene oil is used to some extent for timber preserving on a small scale, being particularly suited to this use on account of very great penetrating and antiseptic properties, combined with unusual stability. A number of trade preparations known in general as "Carbolineum" are prepared from anthracene oil by causing it to absorb chlorin gas. The specific gravity is greatly increased without any lessening of penetrating power, but the object of the treatment is not very apparent so far as the efficiency of the finished article is concerned.

Several of the solid substances accompanying anthracene have, in the pure state, a restricted use as chemical re-agents.

Free Carbon, in the form of a fine powder, occurs in almost all tar, the percentage being very small in low-heat tars, while in tars made at very high heat (*e. g.*, Lowe crude-oil process) it forms a large part of the tar. So far no use has been found for this material, except as fuel under certain conditions.

It separates spontaneously from thin tars on standing; from thick tars it may be separated by centrifuging or filter pressing. On adding a large amount of light tar oil (heavy tar oil is not very satisfactory) to a heavy tar it

will settle out, and may be washed clean with benzole, or with a number of more expensive solvents for tar. In the pure state it is a moderately coarse, amorphous, gray-black powder, much too hard and coarse for use as a substitute for true lamp-back.

Ammonia and a number of its compounds, as well as cyanides and sulpho-cyanides, are obtained from the alkaline water accompanying coal tar. None of these bodies are found in oil-tar liquor, which consists practically of water holding in solution a slight trace of naphthalene and dihydric phenols.

Basic Bodies (pyrrhol, pyridines and quinolines, etc.) are found in all tars, mostly in low-heat coal and oil tars. They may be separated by treatment with dilute sulfuric acid, precipitation with alkali, re-distillation and fractionation. So far almost no use has been found for these substances in commerce.

Drugs. Most of the synthetic preparations from coal tar, now so important in medicine (*e. g.*, antipyrine, acetanilide, hydroquinone, saccharine) are made indirectly from benzol; phenacetin is made from carbolic acid. The high price of most of these products is due either to patents or to difficulties attending their manufacture, the cost of the original tar materials being but a small part of their value, so that while they are individually of great importance, they cut almost no figure in the prospects of the tar-refining trade.

SOME SUGGESTIONS ON OPERATION AND CONSTRUCTION IN THE ELECTRIC DEPARTMENT.*

BY GEORGE C. HOLBERTON.

During the last few years, the writer has had occasion to visit a great many gas and electric plants in towns scattered over about 300 miles of this State and varying in size from a population of say 110,000 down to 1000 or less, and to note their methods of operating and constructing.

In no two places are conditions absolutely identical, but there are a great many general suggestions that would apply to all and possibly some of these suggestions, ideas, rules or whatever else you may choose to call them may prove of interest to you.

METERS.

A great many of our California towns are supplying current on a flat-rate basis, but in all of them there are at least a few meters. I do not care to enter into a discussion of the relative merits of meters and flat rates, but would like to try and give you a few suggestions as to the selection and care of meters.

There are two general classes of meters, commutator type and induction type. The use of the induction type is confined to alternating current, but the commutator type can be used on either direct or alternating. For ordinary use, especially where there are not a great many meters, the induction meter is to be preferred, as it will remain accurate over longer periods with less care than the commutator type.

Assuming, then, that in general we use induction meters, we now come to the selection of the particular meter best suited to each case. I do not here refer to the make of meter, as I am not in the advertising business, but to the general type.

For ordinary lighting work and for single-phase motors, a simple single-phase meter either two or three wire as may be required, should be used, but when it comes to poly-phase motors there is room for discussion. I think that for two-phase motors it is probably better to use two single-phase two-wire meters. This form of registration will be accurate, and should you lose your motor customer your two meters become available for lighting or other purposes. Also, should one meter stop, twice the registration of the good meter would give you an approximate registration. As to the relative cost, take for example a fifteen horsepower 200-volt two-phase motor, we find that two 50-amp. meters would cost say $45, and a poly-phase meter would cost the same, so there is no advantage from this point of view in favor of the poly-phase meter. The main advantage would be that of having in the case of the poly-phase only one dial to read and take care of on the books.

In the case of a three-phase motor there are three possible arrangements: one poly-phase meter, three single-phase meters and two single-phase meters. I believe the first of these is to be preferred. The second is more accurate, but is too expensive and too complicated except in very large installations.

The third case is all right under some conditions, but with a low or varying power factor gives rise to trouble. In 1903 Mr. Decker gave us a very interesting paper on "Our Customers and Their Complaints" and told what to do when they kicked about high bills. Since then Mr. Decker has had two meters on a three-phase motor in a planing mill, and perhaps he can tell us what to do, when at the end of the month the meter showed that he owed his consumer something for the privilege of operating his mill during the month.

Even in large installations the poly-phase meter will be found almost as accurate as the three meters and much more simple to read and keep track of. I think the reason it is not used more than it is, is mainly that it is hard to get out of San Francisco stock, whereas the small two-wire meters can almost always be obtained.

There is one other point in the selection of the proper type of meter that I would like to touch on, and that is the use of the so-called primary meter. That is to say, a meter in which the primary (2000-volt) current actually passes through the meter. These meters should never be used under any circumstances. If you have a contract with a consumer which calls for the measurement of his 2000- or 4000-volt current, use ordinary five-ampere 100-volt meters with both current and potential transformers, even if his primary current is so small that your current

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

transformer has a ratio of 1:1. This also applies to switchboard work, as I believe it is generally conceded that no current over 600 volts should be brought to instruments or switches on the face of the switchboard. In fact, the writer is now designing a sub-station where no current over 600 volts even enters the same room as the switchboard, except the one lead coming up through the floor to the synchronous motors of the motor generator sets.

Having discussed the character of meter to be employed I would now like to bring to your attention the matter of the proper capacity. In a general way from my observation I feel perfectly safe in stating that ninety per cent. of the meters in the average town are installed too large. This subject has been brought up in a great many articles on the care and management of meters. All these articles treat the matter in a general way. In order to impress on you the importance of this matter, I propose to give you a specific instance showing how meters are sometimes installed. The following is an actual existing condition in a small California town:

The company owns a total of seventy-two meters, nine of which are in their warehouse for either stock or repairs and the balance of sixty-three are on their lines. Of these sixty-three, twelve are used for power, leaving fifty-one lighting meters. The records of four of these were not quite clear as to the size of meters or number of lights connected, leaving forty-seven meters of which there was a complete record.

The total number of lights in the equivalent of sixteen candle-power lamps connected to these meters is 1255, whereas the total capacity of these meters in sixteen candle-power, burning continuously, is 2670. That is to say, if all the lights connected on the meters were to be turned on at once and left burning continuously, the capacity of the meters would still be more than double that necessary to carry the load. As a matter of fact, however, all lights are rarely turned on at once, and also a meter is capable of standing quite a considerable overload, so that there really exists a still greater discrepancy between the capacity of the meters and the number of lights installed than that herein noted.

There are two great objections to this condition of affairs. First, the fact that the accuracy of registration, that is to say, all night registration, is greatly impaired, and secondly, the fact that you have an unnecessary investment. Concerning the first objection, I think it is evident to us all that the nearer the normal load the meter is worked the better the registration; also, if, as is often the case, one or two lamps are left burning, the smaller the meter the more chance of getting registration of this extremely light load. The writer has in most cases been able to so install house meters as to get registration of what is known as the baby filament in a Hylo or Edison night lamp without having a meter that crept.

Regarding the second objection, would state that the value of these forty-seven meters is approximately $590.50, whereas the value of a properly selected batch of meters to do the work would be about $476.50, showing an over-investment of more than twenty-five per cent. So much for the selection of the proper meter, we now come to the method of installation.

In all the larger companies, I believe it is the general practice to test the meter as received before installing same in its location on the consumer's premises. In the case of smaller companies it would be well to at least, after unpacking the meter, examine same very carefully and make an approximate test, making sure that the meter is approximately correct and free from any great defects. Care should be used in transporting meters from the storeroom to the consumer's premises. Modern meters are so constructed that it is no longer necessary to wedge the disks with wooden or paper wedges as this is taken care of by more simple methods, but even so it is better to exercise care in transporting the meters. It is also of great importance to see that the meters are located in a proper position on the consumer's premises. In selecting this location, there are three main points to be observed. First, the meter should be so located as to get good registration, that is to say, it should be located away from any vibration, dampness, or undue amounts of dirt and dust. In the second place it should be so located as to be readily accessible for testing and cleaning, and third it should be located where it is easily read.

It was only a few years ago that it was quite common to see the statement taker with a step-ladder on his shoulder going his rounds to read electric meters. In fact, the writer has seen a great many instances where the meter was located in bathrooms and other inaccessible places, making it necessary for the statement taker to make several trips owing to the cleanly habits of the occupants of the house.

In Oakland we are having a very rigid system of inspection. Service is not connected to a house unless a meter loop is located in a position approved by the company's inspector. This is generally on the back porch within six feet of the ground, or in the case of a house having a high basement it is often located in the front end of the basement and a door cut in the side of the house opposite the meter, so that the statement taker has only to enter the front yard, open the door and read the meter, the high basement making the meter readily accessible for cleaning and testing. After the meter is properly installed it should not be assumed that it needs no further care. The meter should be tested when installed, after which it should be periodically inspected. The frequency of these tests and inspections depends upon the character of the installation, both the conditions under which the meter is installed and the revenue derived therefrom tend to determine its factor.

In the larger towns under the writer's supervision we make two distinct classes of inspection. One class is the taking care of suspicious meters, that is to say, meters where either the registration has stopped, fallen off or very materially increased, or where the customer has complained of the amount of the consumption. The

other class of inspection is a periodical one and covers all meters whether they show any suspicious registration or not. The condition of the meters when inspected will soon demonstrate the period which may be allowed to elapse between inspections. We find some meters need a very frequent inspection due to vibration, all of which cannot be overcome and which tends toward inaccuracy of the meter, particularly in the commutator type of meters. In larger towns, however, where there are many meters, a great deal of discretion should be exercised in the character of the test made on the meters. For instance, it is clearly evident that in meters whose registration is below the minimum bill, it would be a waste of time to attempt to make the meter register within a fraction of one per cent., whereas in large meter installations, of which the writer has one installation showing an extreme condition, where the bill amounts to in the neighborhood of $12,000 per month, it is necessary to get the most accurate registration possible. In this case, were the meter even three-quarters or one per cent. slow it would pay the meter inspector's salary if he did nothing else but watch these meters all day long. These meters are watched continuously and kept in perfect order and elaborate tests are made every few months, and where there is the slightest falling off in the reading, unless there is some good reason for such falling off, they are made oftener.

To test these large meters and get them within a fraction of one per cent. requires a great deal of care and time as well as very accurate and expensive instruments. For testing the smaller meters, this extreme accuracy and care is unnecessary. A man whose bill is two or three dollars a month is not very apt to complain even if the meter is five per cent. high, whereas it is very easy to adjust a meter within one per cent and to test a great many a day.

The writer with the assistance of Mr. Knopp, who has charge of the meter department in Oakland, has devised a testing set for use in testing small meters, which is very easily and rapidly manipulated. Our weekly meter test reports show that one man working eight hours a day will test about fifteen meters, including the time for connecting and getting from place to place. Also including the adjustment of the meter and the putting of same in good condition.

Thinking some of the members might be interested in this test-set, I have brought one here for your inspection. The outfit is extremely simple, consisting of an ammeter and a portable load with a variable resistance for taking care of the different voltage found from house to house, or at different times of the day. In all meter formulæ you will generally find the constant 3600, representing the number of seconds in an hour. This causes a complication in figuring the exact speed of the disk. To overcome this Mr. Knopp has made a watch in which the gears have been changed so that the watch reads directly in what he styles millihours, that is to say one-thousandth part of an hour. By measuring the speed of the disk in millihours you eliminate the constant 3600, also by properly adjusting the load to the calibrating constant of the meter, you can use the meter disk to make revolution, when accurate in 100 of the watch divisions (10) millihours. All that is necessary is to take the speed of the disk with the stop watch, and if the watch reads ninety-six of these divisions in place of 100, ninety-six one-hundredths becomes the correct factor of the meter. In other words the meter is about four per cent. fast and this actual reading multiplied by ninety-six one-hundredths will give the correct reading of the meter. On the other hand if the disk makes a revolution of 104 divisions the meter is approximately four per cent slow and the reading of the meter should be multiplied by 104-100 to get the correct reading. The instrument is also so constructed that in a four-hole meter only two wires are removed and the only operation is that of slacking off two set screws and slipping the instrument connectors into the meter in place of the house and service wires and then placing the house and service wires into these connectors.

We have also a more elaborate testing set which is used for testing where extreme accuracy is wanted and where we have to test various types of meters, including polyphase meters and those covering wide ranges. This set will test meters having a capacity of from five to 200 amperes and voltages from 100 to 500. This instrument is also on exhibition if you care to inspect same.

I should, perhaps, apologize for taking up so much of your time on the meter business, alone, but I feel that this is a very important matter in connection with the supply of electricity, as a very small error in your meters will make a very large difference in the revenue of your concern.

In this connection there is just one other experience which might interest you, and that is a case which came under the writer's observation. There were installed a number of old-style meters which had been in service for some years. The writer removed from one plant about 150 of these meters at a cost of about $1,000, including the labor of making the change. The result was that where consumers had been paying the minimum bill of one dollar per month, their bills jumped to two and two dollars and a half, and where bills have been running along at one dollar and half and two dollars per month, the bills increased to three and four dollars per month. It does not take a very large sheet of paper to figure the advisability of discarding such meters.

KIND OF SERVICE.

Leaving now the matter of meters, I would like to offer some suggestions in connection with the character of service, that is to say, as to the kind of service best suited for secondary distribution in the smaller towns, also in the residence and outlying districts of the larger towns. In 1901 the writer read a paper on " Comparison of Methods of Secondary Distribution of Alternating Current " in which he advocated the use of 200-volt service supplied from a three-wire secondary with 400 volts

across the outside, the service being connected between the outside and the neutral. Since the reading of that paper the writer has had four years' experience in Oakland, in the installation of 200-volt service, and I would state that outside of a few three-wire 200-volt services installed in the congested down-town district of Oakland, nothing but 200-volt services have been placed. We have no trouble whatever in obtaining lamps, fans and other appliances and the installation in a number of ways has been a perfect success. We do not always run the 400-volt three-wire secondaries at the start, but often run a straight two-wire 200-volt distribution; then as the district grows and we get a sufficient number of consumers we run the third wire and balance up the load. This has resulted in an immense saving in copper and transformers, the copper being one-sixteenth of what it would be for 100 volts, and it has enabled us to use much larger transformer units than could otherwise be used, also the saving in meters has been considerable. A small 200-volt meter, such as is used in residences, cost eighty cents more than a 100-volt meter of the same ampere capacity, and is good for twice the number of lamps.

I trust that it will be your pleasure to discuss these points as the writer is of the opinion that this practice should be universally adopted in the smaller towns and outlying districts of larger towns as above mentioned.

I had intended to take up a number of other subjects such as pole-line construction, type of transformers, etc., but I find that the paper has already become longer than I anticipated at the start, so I will not tax your patience further. If this paper invites some discussion I shall feel rewarded for my efforts and will in another paper, at some future date, be glad to offer some suggestions along other lines covering different portions of the electric end of our business.

SOMETHING ABOUT THE PHYSICS AND THE CHEMISTRY OF ILLUMINATING GAS.*

BY F. C. JONES.

In the manufacture and the sale of many commodities the manufacturer neither knows, nor cares to know, the chemical composition of his goods. In the manufacture of such things as steel, glass, sugar, however, a knowledge of the exact composition of the product is indispensable for the attainment of uniformity of results.

In this latter class of commodities we must place illuminating gas, for, very often, only chemical analysis and photometry will show whether the gas is being made with proper uniformity and economy.

At the risk of repeating what you all know, I will review briefly the physical and chemical characteristics of the constituents of illuminating gas, and then outline their quantitative determination.

Ordinary illuminating gas, by which I mean coal gas, carburetted water gas, and the more recent crude-oil water gas, contains seven constituents, three of which are elementary gases, three compound gases, and the remaining one a group of compound gases.

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

1. Oxygen, an elementary gas, specific gravity 1.1056 (air = 1.000) will not burn in air, but is a perfect supporter of combustion. It exists in illuminating gas in quantities usually ranging from a trace to 0.6 per cent, and is familiar to us in our atmosphere, of which it composes more than 20 per cent.

2. Nitrogen, an elementary gas, specific gravity .97137, is non-combustible and does not support combustion; it composes nearly 80 per cent of our atmosphere. It is found in illuminating gas in quantities ranging from 1.0% to as high as 15.0%. The source of both oxygen and nitrogen in carburetted water gas, and crude-oil water gas is the air used for maintaining the *heats*. In coal gas, air is shoveled in with the charges.

3. Hydrogen, also an elementary gas, specific gravity .06926, will not support ordinary combustion, but itself burns with a blue, non-luminous flame, forming water. Its sources in carburetted water gas are the steam and the hydrocarbons of the oil. In crude-oil water gas, a small amount of hydrogen is derived from the reaction of the steam with the incandescent carbon; the greater amount, however, is due to the breaking down of the hydrocarbons.

4. Carbon monoxide, commonly called carbonic oxide, is a *compound* gas of the formula C O, a single atom of carbon tied to a single atom of oxygen. It has a specific gravity of .9674; it burns with a flame similar to that of hydrogen, taking up one atom of oxygen to form carbon dioxide. Carbon monoxide exists in gas in quantities ranging from a fraction of 1.0 per cent. to 25 and 26 per cent. Crude-oil gas seldom contains over 5.0 per cent., often, relatively, much less; carburetted water gas, on the contrary, almost always contains at least 24.0 per cent. The sources of this gas are the combination or carbon with the oxygen of the steam, or the combination of carbon with the oxygen of carbon dioxide.

5. Carbon dioxide, the higher oxide of carbon, is a compound gas containing one atom of carbon united with two atoms of oxygen, $C O_2$. Its specific gravity is 1.529. It neither burns nor supports ordinary combustion. It is found in gas in quantities as low as 0.2% and as high as 13 or 14 %. Its sources in gas are the combination of the oxygen of the steam with carbon, or with carbon monoxide, and the combination of the oxygen of the blast with carbon.

6. Marsh gas, another compound gas, $C H_4$, the first member of the paraffin series, has a specific gravity of .556, and burns with a slightly luminous flame forming water and carbon dioxide. In carburetted water gas and in oil gases it is derived from the oil. Its quantities vary greatly from 18 per cent. in the former to 40 per cent in the latter.

Each of the six foregoing gases is of fixed, definite, chemical composition; each is odorless, colorless, and, with the possible exception of carbon dioxide, tasteless.

7. The seventh comprises the group of hydrocarbon gases, other than methane, combinations of carbon with hydrogen, such as C_2H_4 (ethylene), C_3H_6 (propylene),

C_4H_8 (butylene), also the vapor of benzene or benzol (C_6H_6), all of which average very fairly as C_2H_4 (ethylene), having a specific gravity of .9674. These unsaturated hydrocarbons have various odors, etherial or aromatic, pleasant or the reverse, the combination of which produces the odor of gas. They all burn with luminous flames, and if supplied with the proper amount of oxygen form water and carbon dioxide.

The analysis of gas is effected by collecting a measured quantity of the gas in an accurately graduated burette, and, by means of a mercury leveling bottle forcing the measured sample into successive re-agents that remove one constituent after another. Just as if you had a tin measure filled with a mixture of sugar, sand and rock salt. You could pick out the rock salt, note the dimunition in volume, wash out the sugar and the sand would remain. You would then have determined the volume percentages of the three. While such a method would be worthless in the case of solids, in the case of gases, per cent. by volume is exactly what we wish to know, for gases, you will remember, combine not only by definite weights but also by definite volumes.

As the salt, sugar and sand had to be separated for obvious reasons in the order named, so, in gas analysis, there is an order fixed by necessity, depending on the behavior of the constituents toward the re-agents.

The apparatus, which I wish to call to your notice, is one devised by Mr. L. P. Lowe; it combines the best features of the Hempel and the Orsat apparatuses, and it combines rapidity with accuracy.

Mercury should be used as the confining liquid, instead of water, first, because all of the gases are soluble in water, their solubilities differing from each other and changing with the temperature; secondly, because water adheres to the inside of the burette making the capacity appreciably less.

The burette is filled with mercury by raising the leveling bottle. Gas is admitted slowly until the burette contains a little more than 100 cubic centimeters, when the three-way stop-cock at the top is closed. The leveling bottle is now raised, compressing the gas to less than 100 cubic centimeters, the rubber connecting tube is pressed between the thumb and fingers, and the mercury in the burette allowed to flow back exactly to the zero mark. Now, when the stop-cock is opened for an instant to the air, the excess of pressure in the burette drives out the small excess of gas and we have left exactly 100 cubic centimeters at the atmospheric pressure of the laboratory.

The gas is passed into the first pipette, containing a 33⅓ solution of potassium hydroxide. This removes carbon dioxide by combining with it to form potassium carbonate.

Next, the gas is passed several times into fuming sulphuric acid, which removes all the unsaturated hydrocarbons, by seizing the hydrogen and depositing the carbon. The products of this reaction, together with the fumes of the acid must be removed in the potassium hydroxide pipette. It is now clear why we first removed the carbon dioxide.

The oxygen is abstracted by either phosphorus or pyrogallate of potassium. If the former is used, it will act only after the last trace of illuminants has been absorbed, thereby confirming the accuracy of the analysis to this point.

The last direct absorption, that of carbon monoxide, is effected by a hydrochloric acid solution of cuprous chloride, which forms an unstable compound with the carbonic oxide. It is best always to have two pipettes of cuprous chloride solution. If one has done more absorption than the other, pass the gas into this one first, letting it remove all the carbon monoxide it will, then pass to the fresher pipette, just as one uses the relatively clean purifying box last of all. The much worked first pipette may remove four-fifths of the 25 per cent. of carbonic oxide in carburetted water gas, and upon another sample of the same gas, it will remove four-fifths, yet the last fifth requires fresh reagent.

Up to this point we have removed by absorption, in the case of oil gas 15 per cent., in that of carburetted water gas 40 per cent. of the sample. Since hydrogen is absorbed only with difficulty by palladium oxide, and marsh gas and nitrogen are not absorbed by any re-agent, so far as I know, the determination of these three gases is effected by the explosion of a measured quantity with air or with oxygen and air. By noting the contraction caused by the explosion, and afterward measuring the carbon dioxide formed from the carbon of the marsh gas with the exygen of the air admitted, the amounts of hydrogen and marsh gas are easily calculated. Two very simple reactions take place:

1 $2\,H_2 + O_2 = 2\,H_2O$

2. $C\,H_4 + 2\,O_2 = C\,O_2 + 2\,H_2O$

In each reaction water is formed. In reaction No 1, two volumes of hydrogen unite with one volume of oxygen, and, if the temperature were high enough, there would result two volumes of steam. There would be that chemical shrinkage from three volumes to two. With this chemical shrinkage, however, we have nothing whatever to do. The contraction with which we are concerned is a physical one, resulting entirely from the different phyical state of the product from its components. Eight cubic centimeters of hydrogen, for example, have united with four cubic centimeters of oxygen to form an amount of water so minute that it cannot be measured in a burette. The combined hydrogen of the marsh gas has selected its proper amount of oxygen and has done exactly the same thing. In reaction No. 2 we see that the marsh gas has formed its exact volume of carbon dioxide. Absorption, therefore, of this carbon dioxide will give, directly, the amount of marsh gas in the portion of gas exploded, and the ratio of this amount to the portion of gas exploded will, of course, be the same as that of the total marsh gas to the total amount of the marsh gas hydrogen and nitrogen.

We can now work back to the free hydrogen. Since the marsh gas has been responsible for the disappearance of twice its volume of oxygen by multiplying the amount of marsh gas (as shown by absorption) by two and sub-

tracting the product from the explosion-contraction, the difference will be the amount of contraction, had there been no marsh gas present. Two-thirds of this amount will be the amount of hydrogen in the portion of gas exploded. The total free hydrogen is then calculated by simple proportion.

Nitrogen is the difference between the sum of the correct amounts of all the other constituents and 100 per cent.

SHORT TOPIC.*

BY E. C. JONES.

At the meeting of the American Gas Light Association, held in Washington, D. C., October 19, 20, 21, 1904, a paper on the subject of "Consumers' Meters" was read by Mr. Brewster H. Spangenberg, superintendent of meters for the United Gas Improvement Co. at Philadelphia.

As an introduction to this topic, I would say that every member of this Association should read this excellent paper, and after having read it he should read it again. Mr. Spangenberg has covered in his paper the work performed by the ordinary meters now in use, and the possibilities of important improvements in these meters without great change or expense.

This topic is not intended to simply eulogize the splendid and exhaustive work done by Mr. Spangenberg, but to call to the attention of those among us who have not read his paper that they are in duty bound to do so. My remarks anticipate that every one present has read the paper, which was published in the *Progressive Age* of December 1, 1904, the *American Gas Light Journal* of November 14, 21, 28, December 5, 12, 1904, together with the discussion.

Some of these meters have been made by Messrs. Helme & McIlhenny and Messrs. John J. Griffin & Co., meter manufacturers, both of Philadelphia, and through their kindness we have a sample of the Spangenberg five-light meter, and another with prepayment attachment. There is nothing particularly new about the prepayment attachment, as there are over 100,000 of this kind now in use. The cash box, however, is new.

The sample five-light meter was sent out from the East, stripped and after careful examination of it, it was set up and tested and stripped again for your examination. This meter was made by Helme & McIlhenny of Philadelphia, marked

200

5 A cu. ft.

HELME & McILHENNY,

Philadelphia,

700520

The valves are the same size as the valve of an ordinary twenty-light meter. The diaphragms are of special size, eight inch instead of nine inch, as in the regular five-light meter. The channel of the inlet is above the table instead of below, and is much larger than usual. The clam-shell is larger and the pockets are larger. The index on this meter registers to 1,000,000 cubic feet, instead of to 100,000 cubic feet, as in the ordinary five-light meter. The meter has two test dials, each divided into tenths, one registers two cubic feet, the other two-tenths of a cubic foot. The valve arms are shorter, and are made of heavier stock. The crank shaft is larger and the king post heavier and longer. The flag arms are wider and heavier, and there is more room allowed for packing. The gallery is seven-sixteenths of an inch higher than in ordinary meters, and the center stuffing-box is arranged so that it can be packed without stripping the meter; that is, taking off the worm and king post and the tangent.

This feature alone is valuable, and the foreman of the Oakland meter shop was criticised ten years ago by one of the most prominent meter manufacturers in this country because he insisted that every meter should be made so that it could be packed without stripping.

The following are brief records of tests of the new meter compared with a few other meters now in use.

July 10, 1905.

H. & McI. (Spangenberg).

Water .....70° Fah.

Air .....74° Fah.

Tests with 8 burners.

2 feet = 1′ 56″ (O.K.) = 62 feet per hour.

Check.

2 feet = 2′ 51″ (O.K.) = 42 feet per hour.

Open.

2 feet = 23″ (O.K.) = 313 feet per hour.

July 10, 1905.

John J. Griffin. J A 200 feet. No.800750

Water .....70° Fah. ..

Air .....74° Fah.

Tests with 8 burners.

2 feet = 1′ 56″ (O.K.) = 62 feet per hour.

16 revolutions as in Helme & McIlhenny.

Check.

2 feet = 2′ 50″ (O.K.) = 42 feet per hour.

Open.

2 feet = 23 2/5″ (—2) 313 feet per hour.

Small flame test.

Meter perfectly tight and registers.

July 11, 1905.

Standard five-light. No 47210. 15 revolutions per 2 cu. ft.

Tests with 8 burners.

2 feet = 1′ 55″ = (O.K.) = 63 feet per hour.

Check.

2 feet = 2′ 52″ (O.K.) = 42 feet per hour.

Open.

2 feet = 37 1/2″ (O.K.) = 192 feet per hour.

Small flame.

O. K. perfectly tight.

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

July 11, 1905.

Pacific Meter Co. five-light. No. 12599. 12 revolutions per 2 cubic feet.

Tests with 8 burners.

2 feet = 1′ 57″ (O.K.) = 62 feet per hour.

Check.

2 feet = 2′ 49″ (O.K.) = 43 feet per hour.

Open.

2 feet = 45″ (O.K.) = 160 feet per hour.

Small flame. Tight.

July 10, 1905.

Ohio Gas Meter Co. five-light. No. 5326. 12 revolutions per 2 cubic feet.

Test with 8 burners.

2 feet = 1′ 52 2/5″ (O.K.) = 64 feet per hour.

Check.

2 feet = 2′ 56″ (O.K.) = 41 feet per hour.

Open.

2 feet = 43″ (O.K.) = 167 feet.

Slow 5″ pressure.

Perfectly tight and registers.

Ordinary five-light meter.

The Spangenberg meter must of necessity be more expensive than the regular five-light meter, but the greatly enlarged capacity of the meter must be taken into consideration, as the five-light size will take the place of a ten- or twenty-light meter, and as gas consumed per meter is rapidly increasing this meter will care for the increase.

It seems that meter manufacturers have some doubts as to the complete success of Mr. Spangenberg's improvements. To quote one, "The query as to this meter is the effect upon registration, of condensation upon the valve. Our judgment is that it will be better to not introduce these meters generally until some have been used for a year or two."

Another manufacturer says, "As you know, the meter is in the experimental stage, and we are feeling our way with it."

Another large company says: "Everyone in our company is hopeful regarding the new meters, and I know of one other company which will order quite a supply of them as soon as the manufacturer is able to make them."

The improvements made by Mr. Spangenberg are in the right direction, and the development of this meter will be watched with interest.

HOUSE PIPING.*

BY GEORGE KIRK.

I have been requested to say a few words on house piping. I can only give you my experience with gas pipe in houses as I have found it during the last thirty years, as inspector for the Oakland Gas, Light & Heat Company. During that time I have had considerable experience with gas fitters, whom I find as a rule need watching, both in regard to the size of pipe and the manner of placing same in the house.

As a great deal of the work of cutting the pipe and putting on the fittings is done by boys who are always looking for an easy job, much small pipe, rather than larger pipe, gets into the work, if the fitter can get it in and covered before the inspector sees it, for when the plumber gets his certificate there his trouble ceases and the gas man's trouble, as a rule, begins, and plumbers use all the talent they have to fool the inspector in such cases.

I have found them resorting to all kinds of tricks known to the trade to get the pipe so that it would stand the test. I will only mention one or two, as I know most of you gentlemen have had as much or more experience than I have had.

In some cases I have known them to fill the pipe with salamoniac water, muriatic acid and the like, to rust the pipe in hopes of stopping the leak and keep it tight long enough that the job may pass inspection. We know that pipes, at best, rust soon enough, without any aid from the plumbers.

On account of the stoppages in pipes, caused by rust and condensations, some years ago the Oakland Company changed the rules governing the size of pipe, increasing same very materially from the size then in use, and since then has had little or no trouble.

Three-eighths-inch pipe is used only for brackets or side lights. No horizontal pipe less than one-half inch and house riser less than three-fourths. I find that if pipe less than the size specified in our rules is used, we are liable to have more or less trouble with stoppages in the same, caused by the following reasons:

The majority of gas fitters use the three-wheel cutter to cut the pipe, which leaves a burr inside at each end and diminishes the size of the pipe. The gas fitter then is using lead or cement in his fittings, places the same inside of the coupling or fitting and not on the threads, as should be done. The result of this is that more or less of the material is forced inside and against this burr, leaving a very small opening in the pipe.

Although this is the time of high-pressure and small pipes for street mains, I cannot see where we can lessen the size of house piping with any assurance of satisfaction to the consumer. However, it will always be necessary to use a governor and low pressure on the house pipes, as very few if any gas fixtures would stand one pound pressure.

In considering the placing of house pipe for either illuminating or fuel purposes, the prime object to be sought is the safety of the occupants.

Under this heading comes the question of the use of black or galvanized fittings. I consider the use of black iron fittings on gas pipes concealed within the walls or under the floors of a building a constant menace to the general public, as black iron fittings are known to have more or less sand holes in them, and sometimes very large ones at that. Now, what is the result? When the plumber finds a fitting with one of these large sand holes in it he is

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not going to cut it out, for it will probably cost him a couple of dollars to do so. The result is that he resorts to the use of gas fitters' cement to plaster it up, this being the easiest and cheapest way out of it for him. The inspector will not be able to see same for the simple reason that the plumber knows how to cover it up, so that it cannot be detected by the most critical eye. (From my experience I am sure there should be rigid rule against using gas fitters' cement under any circumstances, on concealed pipes.) Now, what is the result? In a few years the action of the chemicals in the gas will soften that cement, and there is a leak under the floor or in the wall. It is for this reason that I advocate the use of galvanized fittings, exclusively, for house gas pipe.

I also suggest, from the standpoint of safety, that there should be a shut-off in the main pipe on the first floor, and it be marked as the "Gas Stop Cock." This, I think, would be the means of averting a great many accidents with gas.

Such an occurrence happened in Oakland a few days ago, when a man got up about six o'clock in the morning, and going into the hall found the place full of gas. He naturally tried the gas fixtures to see if any were loose, probably not knowing where to shut off the gas. The broken fixture was found, and it was remembered that in carrying out a trunk the night previous this fixture had been struck by the trunk, causing a bad leak near the wall. The fixture was a combination gas and electric, and when the gentleman endeavored to move the fixture the electric wires emitted a spark that exploded the gas which had accumulated during the night.

Now, I believe that if there had been a stop cock on the main pipe, easy of access, and known to him, this accident would not have occurred.

THE INTRODUCTION OF GAS ARCS.*

BY W. M. KAPUS.

With the gas arc the present gas company has great possibilities by which it can largely increase its output, and also to obtain a certain class of commercial lighting which would otherwise be impossible to obtain. The gas arc is to the lighting output what the gas range is for the fuel. The sale of the gas arc, when considering lighting companies, is chiefly advocated by those companies dealing exclusively in the sale of gas, while companies who operate combined gas and electric plants do not take as kindly to the gas arc. It has always been my opinion that gas arcs or, in fact, any gas appliance, can best be handled by the gas company direct, rather than by outside agents, plumbers or gas fitters, whose chief object is the profit they would derive from the sale and which is quite natural, for what further interest would the average dealer have in a gas arc after the same is installed and paid for as compared to the gas company who expects a regular monthly consummation and who should thus be interested that the arc at all times is working properly and giving entire satisfaction to warrant this consummation.

The main success in advocating gas arcs has been due to the fact that the different gas companies have followed a system of free installing and maintenance. Much could be said on this subject, for there is a varied opinion as to which system is the best. I have studied them all and am fairly of the belief that installing an arc free, when the building is properly piped, making no extra charge for the necessary pipe and labor to install the arc the proper height, and even if necessary, to do a small amount of extra piping to satisfy a consumer, together with maintenance free of all expense, furnishing new mantles when necessary, also globes and shades, it being of course understood that all breakage be from ordinary wear and tear, will, in the end, produce the best results. Upon first consideration this may seem to the average gas man as offering too great an inducement to obtain business, but on second ehought, it is our output that we desire to increase, and to successfully succeed some reasonable inducement must be offered.

The cost of a regular four-burner arc complete, with No. 1 grade of mantles, is not over seven dollars and a half; say you install this arc for the state price of twelve dollars, and if paid for at date of purchase or within thirty days, allow ten per cent. reduction, would you not still have a margin between the net cost and net selling price to cover the expense of installing, and a small profit besides, for it is not the profit, in my judgment, derived from the sale of gas appliances, upon which a gas company depends, it is the daily increase of this output, which can not be successfully obtained without gas appliances are within reach of all. If an appliance department can be operated on a paying basis, well and good, but if not, a reasonable loss, if necessary, to create a greater demand for gas, whether for light or fuel, is a loss that will figure a very small percentage on the cost per thousand cubic feet on any annual output, as compared to the volume of new business that can and should be thus obtained.

This system of free installing and maintenance is also a great assistance to the representatives of a company, when endeavoring to set forth the advantages of an arc by being able to state that after the first cost of the arc we do the rest. There are a number of companies who prefer to make a small monthly charge for maintenance. Others believe in renting the arc at a nominal monthly charge; this charge to include all repairs. While all methods bordering on this system will in some measure assist to increase business, the free sytem will produce the greatest results. The company with whom I have had the pleasure of advocating the sale of the gas arc are maintaining all arcs without expense to the consumer and have at present over three thousand in use—the work of a little over two years. We have the city divided into districts, calculating that the average trimmer can properly care for 150 to 200 arcs per week, this number

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depending somewhat on the locations. For example, those in restaurants or similar places, requiring more attention than those in stores or offices. We insist that all arcs must be looked after at least once each week. This work is performed by expert men and men of intelligence, for to do this work properly it takes some education to thus be able to install a mantle, adjust and regulate an arc properly, in order to at all times obtain the very best results. An inexperienced workman can break more mantles trying to get one to burn, than twice the cost of the lamp. There is no economy in this work by having the same done by a lot of cheap boys. A receipt is always taken from the consumer when the arc is looked after, acknowledging what has been done if nothing more than adjusted, we insist upon this receipt. These receipts are filed daily according to streets, and when a complaint is made that our arc is not receiving proper attention for some weeks, these receipts contain valuable information to present on such occasions to demonstrate that our work is not being neglected, and they also serve as a check on our trimmers as to the number of daily stops they make and the material they use. On a basis of 3,000 arcs cared for as per the above system, figuring each arc is cleaned and adjusted four times each month, this would be an equivalent of 12,000 arcs cleaned per month. I can safely make the assertion from my own experience that the breakage of mantles will not exceed ten per cent., which would be 1200 at a cost of ten cents per mantle. To this expense must be added the nominal cost of globes, shades and car fare, which is not to exceed thirty-five dollars for the month, and the cost of labor which to maintain the above number of lights would require ten men at a salary of sixty dollars per month, or a grand total of $755.00 per month, making an average of less than six and a half cents per arc maintained per month which is entirely covered by the pilot light which burns constantly.

There are a number of different make gas arcs on the market, but those constructed with the separate adjustment to each burner are far more satisfactory and better results can be obtained than from those where one adjustment controls two or more lights.

The gas arc, while at present is mostly used for general interior lighting, will also produce most excellent results for either outside or window lighting. When used in exposed locations the only precaution that is necessary is the proper adjustment of the pilot light, in order that the same will not be extinguished while not in use and an escape of gas occur. For window lighting the gas arc will give a most beautiful effect and if used with a mirror reflector it will add still greater to the efficiency of light obtained.

The style of globes used on all arcs have also a great deal to do with the amount of light obtained, there being a number of different styles in use, some of which detract rather than add to the volume of light. An alabaster-finished globe for interior and a clear for outside arc are the style of globes that should be used.

In conclusion I desire to say that in summing up the advantages of installing and maintaining gas arcs, there are many which should receive our attention, and with proper care to the same, results in gas lighting can be obtained which will be beneficial to all concerned.

THE PUBLIC UTILITY CORPORATION AND THE MUNICIPALITY—THEIR LEGAL EQUITABLE AND ECONOMIC RELATIONS.*

BY HERBERT CUTLER BROWN.

I am advised by that truthful and unfailing dispenser of information, the public press, that the labor unions of the country have a law as immutable as those of the Medes and Persians, which excludes attorneys at law from membership in their orders. Whether this law is founded upon an overweening confidence in the justice of their cause, or upon a belief that attorneys are wholly lacking in those qualifications with which the laboring man is endowed by accident of birth, or is compelled to acquire because of mistakes of governments, I cannot presume to say. I can only surmise how convincing an argument that gas men neither labor nor spin must be the presence of an attorney in the membership roll of a gas association.

And yet, why not an attorney among your members? The president of one of the Southern gas companies, on looking over a bill presented by me recently for legal services, took occasion to remark that he wished that his company could get as much for the gas sold by them as they were obliged to pay for that furnished by their attorney. And so after all, it is, I take it, merely a matter of apparatus and process. Fortunately for the legal profession, the gas furnished by it is neither measured by meter nor susceptible of analysis. While the candlepower too often falls in illuminating the dark recesses of the minds of the city fathers, one advantage, however, remains to us in that they have so far made no attempt to regulate the charges which we may make for the gas supplied by us.

But I am grateful that I am permitted by virtue of some small gas interests of my own, and of some large generosity on your part, to be one of your number. A more brainy, energetic and successful organization of men does not exist in the West than that of the Pacific Coast Gas Association, and I deem it an honor, as it is a pleasure, to be among you.

About the time that the argonauts had been on the Pacific Slope long enough to acquire a considerable portion of its golden metals, the tallow candle and pine knot began to pale on them, and they came to demand something better in the way of illumination. Anticipating, as is ever his wont, a possible demand for his commodity, a gas man wandered out to this coast, and he and his friends built and equipped a gas plant. The argonauts got what they wanted, and then promptly proceeded to do what their heirs and successors have ever since been doing—they kicked about it. This is a vice characteristic of mankind when it discovers that it is getting all that it is paying for.

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And when the man who kicks realizes that there is no good ground for his kicking, he straightway wants a law passed so that his habit may have the sanctification of law. The old adage that the more a man gets the more he wants, exemplified no more surely than in the experience of the gas man.

In connection with some matters pertaining to rate regulations, I had occasion a short time ago to make an investigation of the prices charged for gas in this and other parts of the country, and it seemed to me, from such comparison, that considering the greater investment required here, by reason of the enhanced cost of materials and the greater amount of distributing system required, because of the more sparsely settled communities, and the greater cost of fuel and labor, and taking in consideration, also, the difference in output, the consumer on the Pacific Coast has considerably the best of his neighbor in the East in the matter of the prices which he has to pay for gas. Nevertheless, this fact does not seem to appeal to the governing bodies of our cities, and the latter, in some instances, have not hesitated to fix arbitrary rates in entire disregard of all right and equity. While in all private commercial enterprises rights and obligations have been well defined by law, and held inviolate by our courts, yet the public utility corporations have been subject, in the last few years, to persistent attacks from all directions; a few, perhaps, justified by circumstances, but the greater majority more or less unreasonable. I am inclined to believe that this condition is partially due to the harvesting in these days of seed sown in the not very remote past, It is but a few years ago that the manager of public utility corporations proceeded on the assumption that it was furnishing a commodity which the people were more or less bound to take; and, feeling secure in a fancied monopoly, became independent to the point of folly and arrogant beyond reason. Of late years, however, new men have come into control of the business, bringing new methods and new ideas, and the policy of the gas men of the Pacific Coast to-day seems now to be to give the greatest value possible for the money and to furnish the best possible service in a manner the most prompt, considerate and efficient.

In taking up this subject it may be well to consider first the rights of the municipalities.

In England, all rights and powers are primarily vested in a constitution, more or less unwritten, to be sure; but none the less positive and conclusive. In the United States, however, under the theory upon which our form of government was organized, all power is primarily vested in the people, and herein lies a very important distinction between our State and our Federal constitutions. The latter is one of a grant of power only; in other words, no power is vested in the United States Government as such, excepting that which is expressly granted to it by the Constitution and those powers which are incidental or necessary to such grant. This grant of power to the central government is made by the people acting through their State organizations, and what the people have so granted has passed out of their immediate control, and is vested in the Federal Government to be exercised by it alone. All other powers then remain vested in the people, themselves, acting through their respective legislatures. The State Constitution, on the other hand, is not a grant of power, but is one of limitation—that is to say, the legislature of the State, acting for the people, may exercise any power it sees fit, except those which the people, themselves, have either granted to the Federal Government by way of a Federal Constitution, or have expressly taken out of the hands of the legislature by way of a State constitution.

It thus appears that in the State legislature alone, and not in any subordinate body, is vested the will of the people—the sovereign power—and it must control all matters of personal rights and duties, subject only to the State or the Federal Constitution. So the municipality, being a subordinate branch of government, has no legislative power in the strict sense. In short, it possesses no powers or rights whatsoever, excepting those which are expressly granted to it by the legislature, and such powers as are incident or necessary to the carrying out of the powers and rights thus expressly granted. These are fundamental principles which have obtained since the organization of our Government, and are the foundation stones upon which all jurisprudence is built.

It is frequently said that the public streets and highways of a city are, under its implied powers, within the direct control of the municipal government. This is undoubtedly true to a certain extent, but this right of a municipality to control its streets and highways does not go so far as to include, without express legislative authority, the right to part with the control of any portion of the streeets or highways, or to permit their exclusive or partial use by any person or corporation as against any other person or corporation. So that a municipality would not have the power to grant the right to a railroad or gas company to occupy the streets of their city with their tracks or pipe lines without a grant of such power from the legislature. Such use or occupation of the highway is termed a "privilege" or "franchise," and in many of the Eastern States such franchises are granted directly by the legislature of the State to the person or corporation seeking to so use the highway. In this State, however, the legislature has, by a general statute, delegated to the municipality the right to grant such franchises, and determined the manner in which such franchises may be granted and secured by persons or corporations serving public utilities.

Just prior to the constitutional convention of 1879 several efforts had been made to introduce water in the city and county of San Francisco against a monopoly at that time virtually held by the Spring Valley Water Company. Attempts had also been made to introduce gas into the city of Los Angeles against the opposition of the gas company then supplying that city with gas. All of these attempts had been unsuccessful, owing, it was claimed, to the control which these companies had over the governing

bodies in the respective cities. So much feeling had been aroused in this matter that it was determined by the people, through their reprentatives in the constitutional convention, to take out of the hands of the municipal bodies entirely, the granting to and withholding from gas and water companies, franchises for the use of the streets. After long and heated discussions in the convention, Section 19, Article XI. of our present Constitution was adopted, which provides that in any city where there are no public works owned and controlled by the municipality for supplying the same with water or artificial light, an individual or company shall, under the direction of the superintendent of streeets or other officer in control thereof, and under such general regulations as the municipality may prescribe for damages, have the privilege of using the public streets and thoroughfares for the laying down of pipes and conduits therein and connections therewith so far as may be necessary for introducing into and supplying such city and its inhabitants either with gas light or other illuminating light, or with fresh water for domestic and all other purposes, upon the condition only that the municipal government shall have the right to regulate the charges thereof. This section has been construed by our Supreme Court in the Stevens' case, and afterward in the Johnson case as vesting directly in a gas company, by virtue of its organization for such purpose, the right to occupy the public streets and highways of an incorporated city for the purpose of laying down its pipe and supplying the inhabitants of such city with gas, and that such right could not be modified, revoked or abridged by either the municipality or the legislature.

At the time that the constitution was adopted, gas was being used for no other purpose except for illumination, and that by means of the open tip. Afterward, however, when gas came to be used for fuel and for power, the question was raised as to whether or not a corporation supplying gas for illuminating purposes could also convey through its pipes gas to be used for power or heat. It was held in the Johnson case in effect that if the gas company conveyed gas through its pipes for illuminating purposes it was entitled to the occupancy of the streets, although it might at the same time convey through such pipes gas which might be used for purposes of heat and power, or both.

The clause in the constitutional provision providing that the laying of pipes shall be under the direction of the superintendent of streets, or other officer in control thereof, and under such general regulations as the municipality shall prescribe for damages, cannot be exercised by the municipality so as to prohibit the laying of pipes, it having been determined in the Johnson case that such regulations on the part of the municipality must not be unreasonable or prohibitive. This control on the part of the city relates solely to the method of excavating the streets, the time in which such excavations may be left open, the filling of the excavation and replacing of the surface of the street so as to conform to the grade and pavement already established, and the provision as to damages is in the nature of a protection to the city against a failure on the part of the gas company in these respects.

There is, however, in the constitutional provision a final clause which relates to the right of the municipality to regulate the charges at which the commodity carried through the pipes shall be sold to the citizens and inhabitants of the city. Under the former theory as to construction, this clause of the constitution would not be self-executing, but would require an act of the legislature to put it into force and effect. It may be noted that the provision of the Constitution referred to relates both to water and to light. That the constitutional convention did not intend that this provision standing alone should be self-executing, and contain within itself all the machinery necessary to carry it out, was suggested by the fact that that same convention proceeded to adopt a number of other provisions, providing for the manner in which charges should be made or regulated in the case of water, thereby in the constitution, itself, prescribing a means and method by which the municipality could regulate the charges for that commodity. As regards gas, however, the convention adopted Section 33, of Article IV, providing that the legislature should pass laws for the regulation and limitation of the charges for services performed and commodities furnished by gas corporations. By reason of this last clause it was intended in the Pomona cases that, while the constitution provided the machinery for regulating the charges for water, it expressly delegated to the legislature the right to provide such machinery in the case of gas; and, the legislature having failed to enact any law whatsoever affecting this matter in cities having a population less than one hundred thousand inhabitants, that in such cities the municipality did not have the right to regulate rates to be charged for gas. It is to be presumed that in an instrument of the dignity of a State constitution there would be nothing found which could be deemed to have been put there for no purpose whatever. The Supreme Court of this State, however, disposes of this latter section just quoted, by stating that it might relate to gas companies doing business outside of a municipality. As gas companies depend entirely for their support upon the thickly populated communities, and, as such a gas company operating outside of municipalities had never been heard of at the time of the adoption of the Constitution, it is rather of a violent stretch of the imagination to hold that the framers of the Constitution could have had in mind any such condition. The Supreme Court, in the Pomona cases, held, however, that under the final clause of Section 19, Article XI of the Constitution, the power is vested in municipalities to fix the prices of gas. These general principles of law argued by the Court may not perhaps be disputed, but the propriety of their application here is doubtful, particularly as in arriving at its conclusion the Court was obliged to ignore the provisions of Section 33, Article IV, and to construe the last clause of Section 19 of Article XI as a grant of power, rather than a limitation upon the

rights of gas companies, which it might, with equal reason, have been held to mean.

Whether or not the conclusion arrived at is right or wrong, the argument of the Court must, at the most, be a disappointment to the student of law who may take the trouble to read the record. It would seem as though the Court, had it determined to decide in spite of precedence in favor of the power of the municipality to regulate rates, might have arrived at such conclusion by a process of reasoning more syllogistic and consistent.

The powers possessed by municipal corporations are of two different kinds. It is difficult to find words, perhaps, to express clearly these different functions, but we may, perhaps, best define them by saying that the municipality possesses a "governmental function" and a "contractual function," governmental power and a contractual power. This distinction has been recognized by some of the Courts of other States in several instances where such distinction was necessary in arriving at the power as possessed by the municipality.

Under it governmental authority, the municipality exercises its general powers of municipal control, such as those governing the election or appointment of public officials, the collection of taxes, the health and security of its citizens. These powers the board of trustees, or other governing body, cannot abridge by any act on their part, nor can they by any such act deprive themselves of their full and complete exercise. No ordinance passed in pursuance of these powers would convey any vested right which could not be changed or modified at any time at the will of the governing municipal body, or by the legislature of the State. On the other hand, in the exercise of its contractual function, a municipality may enter into contracts, as for instance, contracts for the lighting of public highways, contracts for the building of sewers, contracts for the erection of public buildings, and the like. It is contended that in the exercise of this contractual power a municipality may part with certain rights and vest them in the other contracting party, and of which the latter cannot be divested by any subsequent act on the part of the municipality to which the former may not consent. It is further contended that, included under this contractual power, so-called, is the power to grant franchises or privileges for a consideration. The question then arises whether or not a municipality organized under the general laws of this State may, in the exercise of this contractual function, and under the general laws of the State by virtue of which such municipal corporations are empowered to grant franchises for various purposes, sell to a gas company a franchise for the use of streets and thoroughfares. That is to say, even though there is a provision of the Constitution permitting a gas corporation to occupy the streets of a municipality without a franchise, is the municipality bound by the provision of the Constitution to the extent that it may not, irrespective of that provision, grant a franchise under its general powers to a gas company to occupy the streets of a city and sell gas to the inhabitants thereof? In nearly all of the cities of California the gas companies are, at the present time, operating under franchises granted by the municipality; and, in most cases, for a valuable consideration paid to the city by the gas company or its assignors—franchises granted since 1879, when our present Constitution went into effect. What position, then, does a gas company which has purchased for a valuable consideration such a franchise, occupy with reference to the municipality? Is such a contract of purchase entered into by and between it and the city, within the latter's contractual powers as separate and distinct from its ordinary governmental powers, and does such a contract vest in the gas company rights of which it cannot be divested by any subsequent act of the municipality?

No such provision as that contained in our Constitution exists, so far as I know, in any other State constitution. Under express grants and also under general powers granted to municipalities by the legislatures of the various States, franchises have been sold to lighting companies which have frequently been subject to construction by courts of last resort. In most of the States such franchises have been held to constitute rights vested in the gas company, which, unless some such reservation is made in the grant, itself, or in the general law, cannot be modified or divested by any act of the municipality. While the Supreme Court of this State has intimated that, in view of the provision of the Constitution, to which we have referred, any act of the legislature providing for the sale of franchises to lighting companies is unconstitutionl as against a lighting company seeking to come in under its provisions, yet there have been no decisions rendered by our Supreme Court defining the status of a franchise sold and granted by the municipality for a valuable consideration, irrespective of the provisions of the Constitution. No such question was raised in the Pomona cases, as the city attorney of Pomona claimed the right of the municipality to regulate rates solely by virtue of the constitutional provisions referred to above. A suit has, however, been brought since in the Circuit Court of the United States, Ninth Circuit, Southern District of California, in which the city of Santa Ana had sold and granted to the assignors of the present gas company a franchise permitting the grantee to occupy the streets, subject only to the regulations as to the manner of putting in the pipes, and making no provisions whatever with regard to the regulation of the price which the company should charge for gas. In this case the questions herein discussed are fully presented, and the outcome will be naturally of great interest to all of the public utility corporations of the State.

This brings us to the consideration of the powers of the municipality to regulate the charges which shall be made for gas furnished to its citizens, under the general laws and outside of such a provision as that contained in the California Constitution. One of the earliest cases on this subject was that of the High Court of Equity of the State of New Jersey. The Court in that case held that

the making and selling of gas was not a prerogative of government, but might be done by any person without legislative authority. In 1893 the municipality of Louisville, Indiana, had undertaken to fix by ordinance the price of gas, and the gas company had refused to furnish gas to a consumer who refused to pay the larger rate. The Supreme Court of that State held that the power of a municipality to fix the rates to be charged for gas did not exist either at common law or under the implied powers granted to the municipality by the State legislature, thereby expressly overruled a previous decision rendered by the same Court in the case of Rushville vs. Rushville Natural Gas Company. Up to the present time there has been no decision rendered in any State or Federal Court holding a view contrary to that taken by the Supreme Court of Indiana or the Louisville case. In the case of State vs. Laclede Gas Light Company (102 Mo. 485), the Supreme Court of the State of Missouri, in rendering its opinion against the existence of such power, says:

"It is not open to doubt or dispute that this power to make and vend gas carries with it, as an invariable incident, the right to fix the price of the gas thus made and sold. No other conclusion can be drawn from the premises. A sale implies a price. * * * Whatsoever the law necessarily implies in a statute or in a contract is as much a part and parcel thereof as if expressly stated therein. So that, by the terms of the charter of the respondent company, its rights to fix the price of its product was as much a part of its charter as if it had been, in terms, set forth in section five of the original act of incorporation."

This case and the foregoing rule is cited with approval in the case of the Los Angeles Water Company vs. City of Los Angeles, and the conclusions of the Court in the latter case were sustained on appeal by the Supreme Court of the United States (177 U. S. 559). As there are no authorities to be found holding contrary opinion, with the possible exception of certain expressions found in the decision in the Pomona cases, the municipalities have no inherent or implied powers or rights to fix the rates to be charged for gas, in the absence of mutual contract or of legislative action expressly granting sbuch powers and rights. And where there has been a reservation in the franchise that the pipes should be laid subject to the regulation of the municipal authorities, such reservation has been repeatedly held to not include the right to fix the charges for gas, nor unless such power to regulate the rates was reserved in express terms in the franchise, could it be implied from the general right to occupy the streets and lay down pipes and conduits therein, or to use such pipes for the distribution and sale of gas. In each instance where questions of this character have arisen, they have been decided against the municipality.

The legislature of the State of California has not legislative action expressly granting such powers and passed any law whatsoever expressly authorizing the municipality to regulate the rates which should be charged for the gas, or giving direct or indirect control in this respect to the municipalities, excepting the Statute relating exclusively to cities having a population of over one hundred thousand people.

Among the powers, however, vested in municipalities by the legislature are those commonly called "police powers." These powers have been universally construed to relate solely to those matters which directly affect the public safety, the public morals and the public health. Under these powers the municipality may prohibit or control gambling, the sale and use of liquor, the conduct of pool rooms and places of ill repute. Under the police powers the municipality may also regulate the physical conduct of its citizens so as to most effectually preserve their health, safety and liberty; and under these powers it may regulate the placing of fire escapes upon buildings, the passing of teams on the streets, the speed with which vehicles may be driven through the public thoroughfares, the placing of fenders upon electric cars, and such like matters of regulation and control. While the granting of these police powers has been somewhat in general terms, yet the limitations upon these powers have been pretty definitely settled in this country for a great many years, and it is rare indeed that these limitations have been overstepped by our courts of last resort. Various attempts have been made by the municipalities under these powers to appropriate to themselves the right to regulate the rates which should be charged for gas, but so far their contention has not been sustained by any decision of any court of last resort in the United States.

In the case of the City of St. Louis vs. Bell Telephone Company, (96 Mo. 623) the Supreme Court of that State in considering the question as to whether the City of St. Louis had the power to regulate telephone charges says:

"The city places some reliance on its general power to regulate the use of streets. This power extends to new uses as they spring into existence from time to time, as well as to uses common and known at the time of the dedication or grant of the power to the municipal corporation. The erection and maintenance of telephone poles is one of the new uses; such use is a proper use of the streets. That the company is subject to reasonable regulations prescribed by the city, as to planting its poles and stringing its wires and the like, is obvious. Such regulations have been obeyed by this defendant. Conceding all this we are at a loss to see what this power to regulate the use of streets has to do with the power to fix telephone charges. The power to regulate the charges for telephone service is neither included in nor incidental to the power to regulate the use of streets, and the ordinance cannot be upheld on any such ground."

The court then recites the general welfare clause under which certain powers were granted to the City of St. Louis by the legislature of that State authorizing it to pass all such ordinances not inconsistent with the provisions of this charter or the laws of the State, as may be expedient in maintaining the peace, good government, manufacture. The court then continuing says:

"Under a general power like the one now in question this court has held that the city may pass ordinances con-

cerning vagrants, prohibiting persons from keeping open their places of business on Sunday, and prohibiting cruelty to dumb animals. These matters are all within police regulations strictly speaking, and naturally fall within the domain of municipal legislation and regulation. To say that under this general power the city may fix rates for telephone services, would be going entirely too far."

In the City of Newport vs. Newport Bridge Company, (90 Ky. 193) the City of Newport tried to fix by ordinance the rate of toll which the toll-bridge company should charge for passage. The Supreme Court in that State held in 1890 that:

"The enforcement of this ordinance would not be an exercise of the police power. While it is difficult if not impossible, to concisely define the extent of this power, yet it certainly should not be extended so far as to permit a city to enforce its view of its contracts by penal ordinance, in cases involving neither the morals, health nor safety of its people. It may by ordinance limit the speed of railroad trains or street cars through its streets, and in the same manner regulate any matter which is conducive to the health or safety or morality of its citizens."

In the case of Mills vs. City of Chicago, 127 Fed. Rep. 731, a case now before the Supreme Court of the United States on appeal, the City of Chicago had attempted by ordinance to regulate the rates to be charged consumers for gas furnished its inhabitants. Judge Grosscup of the United States Circuit Court of that district in discussing the question used the following language:

"Has the city the power by ordinance to regulate the rates of gas supply? A municipal corporation possesses only such power as is granted by the legislature in express words, or such as is fairly implied from power expressly granted, or is essential to the specific object and purposes of municipal existence. No one has pretended the regulation of the price of gas is essential to the specific object for which the City of Chicago was created; hence that source of possible power may be dismissed without further discussion."

The Court then referred to the 66th Section of the City and Village Act of the State of Illinois which provides that the city council in cities, and the president and board of trustees in villages shall have the power to regulate the police of the city and village and pass and enforce all necessary police ordinances. Judge Grosscup in discussing this Statute says:

"It is plain to me that this Section, while granting power to regulate the police of the city or village cannot be enlarged to include power to regulate the prices of gas. The power delegated by the State to the city is not the police power of the State. To so construe it would be to invest the city with nearly all the powers of the State—make the city practically a State of itself. Such manifestly was not the purpose of the Section. The Section looked, not to the police power of the State in its wide Constitutional sense, but to a police in the sense of a local constabulary * * * The mere laying of gas pipes and the installation of gas plants, together with their repairs are the subject matter of a power widely separable in circumstances and in substance, from power to deal with the rates at which gas shall be manufactured and sold. The first belongs naturally to the city whose streets are to be occupied, for it is related intimately with the supervision of the streets; the latter with equal reason, is foreign naturally to the city, for the city is one of the parties in interest. The power to regulate ought not, in the usual course of affairs, to go to a party interested. Until there is legislation, more unmistakable than the language used in this Section, to indicate a purpose to grant to a city power to fix rates, I shall not hold that such was the legislative intent. Unquestionably the power resides somewhere in the State, but until consciously delegated to some other body it remains in the State's general repository of power, the general assembly of the State."

I have cited but a few only of the decisions on this point. There are numerous others, all to the effect that under the general delegation of powers by the legislature to the municipality the latter does not obtain the right to regulate the price of gas, but that such power remains vested in the legislature of the State to be exercised by the municipality only as a result of an express and unquestioned grant of such power. It has been held by the Supreme Court of the United States and the various States that a municipality cannot barter away its police powers—that whatever contract a city may make with a private corporation must be subject to its police powers. It has also been held by the same Courts that a city may contract with private corporations for the lighting of the public streets and buildings at a price fixed in the contract, and that such contracts shall be maintained inviolate, and that the price fixed in the contract cannot be changed by the municipality without the consent of the other contracting party.

Such propositions of law—firmly established by repeated decisions—are entirely contrary to the theory that the fixing of rates falls within the police powers of a city. Nevertheless in a concurring opinion in the Pomona cases Justice Shaw of the Supreme Court of this State expressed himself in unmistakable terms to the effect that the municipality could under its police powers regulate the rates to be charged for gas. His opinion does not constitute the opinion of the Supreme Court of the State, although the latter perhaps may be said to intimate in its opinion in the Pomona cases that such would be its decision were it necessary to so decide to sustain the power. Such a decision, however, would be entirely without precedence at this time and absolutely contrary to the theory of our form of government and to the numerous decisions of State and Federal Courts. In view of the wide departure taken by our Supreme Justices in matters of this kind it is impossible to surmise what may be the next step taken by our Supreme Court.

In spite of the apparent impression on the part of many of the governing bodies of our cities the public utility corporation has certain rights to its own which the

municipality must recognize, although from the present state of affairs it would seem that the only way that a proper recognition can be secured is by repeated appeals to the courts. Whether or not the municipality possesses the power to fix the rates which shall be charged for the commodity furnished by the private corporation, nevertheless the municipality cannot legally fix the rate which shall amount to a confiscation of the property of the company. Fortunately for the public utility corporation, it is protected by a provision of the Constitution of the United States which provides that no property shall be taken without due process of law. Our Federal Courts have held that the fixing by a municipality, where such power is vested in a municipality, of a rate which shall be so low that the corporation cannot earn a reasonable rate of interest upon its investment amounts to a confiscation of property and is in violation of the Federal Constitution. Unfortunately, however, as conditions are now in this State this provision can only be enforced by resort to the Courts. In two cases in California which have come within our notice the rate to be charged for gas was fixed by the boards of trustees of the cities in a most unreasonable and arbitrary manner. In each case they were invited to inspect the books of the corporation, examine the properties and make thorough investigation into their operations, but they refused to make such an examination contenting themselves with the mere statement that undoubtedly the books of the corporation were "fixed" and that such an examination would be useless. Unfortunately as a rule our governing bodies are composed of men whose lack of business enterprise and financial success afford them the leisure, without compensation, to look after the affairs of a city. Such men are too frequently men of financial failure. As a rule men who are qualified for such positions are required in commercial enterprises, and can command positions of importance and fair remuneration for their services, and such men will not enter into a political strife necessary to secure offices which are without compensation if not without honor. We do not mean by these remarks to condemn all of the men who are administering municipal affairs in this State. There are many who are not only intelligent but who are fair and just. Unfortunately, however, they are greatly in the minority. The result of this condition of affairs is that the members of a governing board, unacquainted with the conditions and inexperienced in matters of this kind are prone to exercise arbitrarily the power which they believe that they possess in the matter of rates. Because a city of one hundred thousand inhabitants gets its gas for one dollar a thousand the neighboring town of three thousand people believes that it should also have its gas at the same price, regardless of the difference in consumption, and wholly unimpressed by any arguments which men of affairs and experience can make.

As was said by Judge Grosscup in a case heretofore referred to, the power to regulate prices ought not in the usual course of affairs to go to a party interested. And the Federal Court in the Cleveland Gas Light & Coke Company vs. the City of Cleveland (71 Fed. Rep. 512), uses the following strong language:

"It would be a fearful proposition—monstrously absurd and outrageous—if the Legislature were to undertake to confer upon a citizen the right to say at what price services should be rendered to him, or what he should pay for goods and articles furnished him. There is hardly any law in this land that would make the party being furnished, the judge of the price he should pay, or would say that his arbitrary decision should fix the rights of the parties."

And further in the case of the Agua Pura Company vs. Las Vegas, (50 L. R. A. 234) the Supreme Court of New Mexico, a Court composed of justices who are appointed by the President of the United States in the same manner as the justices of the Supreme Court of the United States are appointed, has held:

"It is one of the oldest maxims of law that no one can be judge of his own case. Here not only is the city council the direct representative of the inhabitants of the community, the supplying of whom constitutes the greatest part of the business of this and of similar companies, but as to the supply of water for municipal purposes it is itself a consumer, and is the actual and direct party in interest, with which the water company is obligated to contract. To say that the party which is itself the purchaser should have the absolute power to fix the price at which the owner of a commodity shall sell it to him, would be to state a proposition that no member of the community would for the moment admit if applied to his own business. It is not to be supposed, judging from the known rules of human conduct, that a regulation of price by the purchaser himself would be fair or reasonable; and a delegation of such power by the legislature to one of the interested parties without any provision for judicial review or determination as to the reasonableness of such action, is in itself an unreasonable exercise of the power to regulate, such as renders the act invalid. * * * Without questioning the power of the legislature itself * * * without any provision for a judicial investigation by direct act to regulate rates * * * we hold that the legislature cannot constitutionally delegate such power of the reasonableness of the rates fixed by such authorities, and that the action of the city council in this case, attempting to fix rates, and to enforce their acceptance by a penal ordinance, was therefore unauthorized and void, whether there was a valid contract or not.

And in the case of San Diego Water Company vs. San Diego, (118 Cal. 566) a previous Supreme Court of this State in discussing this question uses the following language:

"The meaning of this Section is, that the governing body of the municipality, upon a fair investigation, and with the exercise of judgment and discretion, shall fix reasonable rates and allow just compensation. If they attempt to act arbitrarily, without investigation, or without the exercise of judgment and discretion, or if they

fix rates so palpably unreasonable and unjust as to amount to arbitrary action, they violate their duty and go beyond the powers conferred upon them."

But litigation in courts is long and expensive. Theoretically our laws are framed and are to be construed to avoid litigation rather than to encourage it. No law exists in this State requiring a municipal body to make any investigation whatsoever as to the reasonableness of the rate which it shall fix for the sale of gas. That such was the intent, however, of the framers of the Constitution is contended by many able attorneys to be apparent from the wording of Section 33 of Article IV of the Constitution before referred to, and which provides that the legislature shall pass laws for the regulation of rates to be charged by gas companies for the commodities furnished by the latter. Nor is it consistent with the policy of the law, nor is it just or reasonable that the method of arriving at a rate to be fixed should be subject wholly to the whim and notice of each individual municipal body without any general rules of formulas for arriving at the result. As it is to-day a gas corporation in one city may have its rates fixed upon a wholly different basis or standard than that applied in other municipalities. As to one corporation the rate might be established upon what would be a fair return upon the cost only of the company's plant, as to another upon what would be a fair return upon its reasonable value, while the municipality may take into consideration the good-will of the business and the value of its franchise, or not as it is arbitrarily inclined. Under the decision in the Pomona cases a municipality may fix the rate at any amount it sees fit. It may fix the rate so low as to amount to a confiscation of the property of the gas company. If the latter does not, because it cannot, accept the rate fixed by the city council its officers and employees may be arrested and thrown into jail. The absurdity of such a condition appears the greater when it is known that the cities are now contending that they can compel by mandamus the operation of the plant should the public utility corporation shut down for any reason whatever, even though compelled to do so because of the imprisonment of its employees or officers. It is true as observed by the Supreme Court of this State that the gas company may have recourse to the courts, but while such recourse is being taken it must in order to avoid the arrest and imprisonment of its officers and employees, charge no more than the rate fixed by the municipality, unless perhaps it may secure a preliminary injunction, which is not always to be obtained and can only be secured by the putting up of bonds. Such litigation is apt to consume a period of months or years, during which time the municipal council sits enthroned in its arbitrary power, and with a disposition not at all in accord with our Republican form of government, controls the local situation.

But as to what facts shall be taken as a basis in determining the amount of the investment, and the expenses of operation to be allowed in determining whether a rate is unreasonable or not, the courts which have been called upon to pass upon the reasonableness of ordinances fixing rates are themselves at variance. One of our State courts has intimated that in determining the value of a plant neither its good will, its operation as a going concern, nor the value of its franchise, may be taken into consideration, yet the Federal Court in the Spring Valley Water Company case recently, in estimating the value of the plant in an application before it to set aside the rate fixed by the supervisors, took into consideration the value of the good-will of the concern. Another court has held that no allowance should be made for depreciation. As to the legal rate of interest allowed on the investment, courts have held that it must be a rate no higher than is ordinarily obtained in such localities on investments of a similar amount, such as on mortgages or loans, ignoring the element of chance in the conduct of commercial enterprises. Another matter to be considered in fixing rates has not been passed upon so far, is that relating to the cost of the raw material which enters into the manufacture of the commodity. In this State where oil is used chiefly in the manufacture of gas the cost of that material is a very important item in the question of rates. Oil fluctuates in value from a few cents a barrel to a dollar a barrel. A rate fixed by a municipality which allows a fair profit upon the investment to-day may next month or next year by reason of the increased market cost of oil, result in compelling the corporation to operate at a loss. In none of the decisions rendered by our courts have we been able to find that unanticipated expenses of a corporation are taken into consideration. No private corporation would be justified in declaring a dividend out of its earnings, until after it had set aside a certain surplus for the coming year to meet such contingent and unknown expenses, as result from accident or fire or similar causes. The difficulty lies in the fact that while the corporation may eventually secure a proper consideration of its rights by recourse to the courts, such proceeding can only be had at great expense to the corporation, and after protracted litigation, during which time the value of its securities are naturally depreciated in a market always influenced by the uncertainties of pending litigation.

The public utility corporation should secure proper and uniform legislation determining the manner in which the regulation of rates shall be arrived at, and declaring also what items of investment, such as good-will, value of franchise, depreciation and rate of interest shall be considered by each and every city in the State of California in regulating the rates to be charged for the commodities furnished. Our Supreme Court would hardly, we believe, go so far as to contend that the power to control the *manner* or method of determining or fixing the rates has been taken from the legislature by any of the provisions of the Constitution. With the present temper of our courts and the disposition of our local governing bodies, such legislation would seem to afford about the only immediate or proximate protection open to the public utility corporation in the State of California. From

my knowledge of such corporations I am satisfied that they want no more than a fair return upon the reasonable value of their investment.

The most important problem of to-day is how that "fair return" and "reasonable value" is to be determined.

THE COMPRESSION AND TRANSMISSION OF ILLUMINATING GAS.

BY E. A. RIX.

The subject of illuminating gas compression is almost a new one with me, and the nature of the gas is so entirely different from that of air that I have been obliged to consider the question mainly from the theoretical standpoint, backed up by a few indicator cards, which have been furnished me by gas compressors. But I can assure you that all of the data which I shall give you is eminently practical, because I have eliminated all of the small variables that are important from a chemical standpoint, but which the advancing piston of a compressor cylinder takes little heed of.

I am not concerned about the candle power or the commercial utility of a gas, but simply with its weight and composition, and what may happen to it after it leaves the compressor cylinder is not the province of this paper.

All gases are sponge like in that they hold various vapors from water vapor to carbon vapors, which they lose to a more or less extent when the sponge is squeezed as in the act of compressing in a cylinder, and what is squeezed out and how much of it is not essential to our discussion, and lies better in the realm of the technical gas engineer.

I have assumed, however, that inasmuch as when we compress a gas the temperature rises in a fixed ratio to the pressures, that there is no direct tendency for a gas to change its physical condition in the compressing cylinder, for an added temperature gives an added capacity for saturation, and this probably increases in about the same ratio as the volume diminishes during compression. So that for commercial purposes I cannot be far wrong in assuming the physical condition of the gases as constant during the range of pressures that will be ordinarily met.

All phenomena of compression and expansion of gases is intimately associated with temperature, in fact the power to compress any gas in foot-pounds is simply the difference in temperature between the gas before and after compression, multiplied by its weight in pounds, by its specific heat, and then by Joules equivalent to convert heat units to foot-pounds. Expressed algebraically, this equation is:

$L = J\,W\,C_p\,(T - T_o)$ where

J is Joules equivalent = 772

W = the weight in pounds avoirdupois to be compressed.

C_p is the specific heat of the gas at constant pressure.

T_o is the initial absolute temperature.

T is the final absolute temperature.

L is the work expressed in foot pounds.

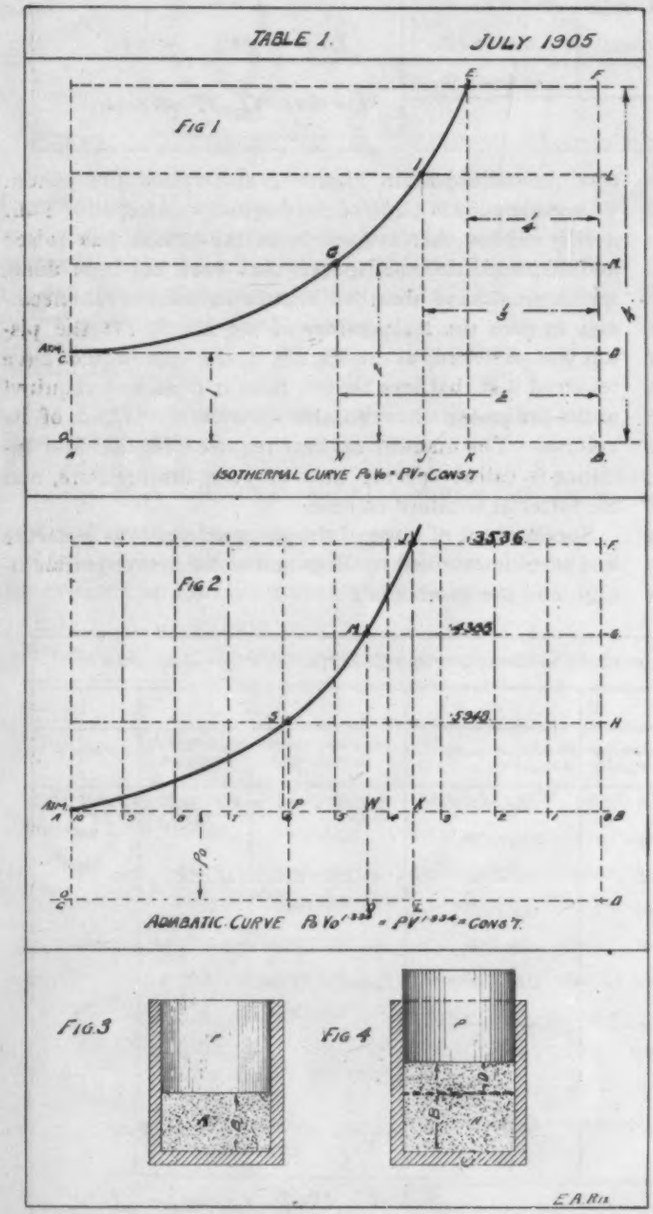
This is the general equation for the compression of any gas.

In glancing at this equation, the first stumbling block we strike is C_p the specific heat of the gas at constant pressure, and this must be first determined. After that, we must discover some means of finding T the final temperature.

To anticipate a little, it may be stated here that these temperatures are all functions of the ratio of the specific heats of gas at constant pressure, and at constant volumes.

It is then our first duty to understand about these two specific heats and to know how to determine them for any gas, and the rest is simple.

The specific heat of any substance is the amount of heat one pound of that substance will absorb to raise its temperature 1° Fah., the specific heat of water being 1.



*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

TABLE 2 CRUDE OIL GAS MANUFACTURED AT OAKLAND CAL BY CALIFORNIA GAS AND ELECTRIC COR JUNE 1905

1	2	3	4	5	6	7
SYMBOL	PERCENT OF VOLUME	WEIGHT PER CUBIC FOOT 32° FAH	C_p	PERCENT OF VOLUME X WEIGHT PER CU. FT.	PERCENT OF VOLUME X WEIGHT PER CU. FT. X C_p	
C_2H_4	7	·0780922	·404	·54664	·220842	$\frac{V_o P_o}{T_o} = R = \frac{144 \times 1}{\frac{.0323577}{492} \times 14.7}$
CH_4	28·3	·044668	·5329	1·26390	·749350	
N	51·9	·005594	3·409	·29032	·989700	$R = \frac{30.36 \times 144 \times 14.7}{492} = 133.2$
CO	5	·0780922	·2479	·39045	·086733	
CO_2	3	·122760	·217	·36828	·079163	$C_v = C_p - \frac{R}{J} = ·6884 - \frac{133.2}{772} =$
N	4·8	·078371	·2438	·37618	·091711	$= ·6884 - ·1725 = ·5159$
O		·089180	·21751			
	100·00			3·23577	2·221563	$\frac{C_p}{C_v} = \frac{·6884}{·5159} = 1334 = Y$
				= ·0323577	·022275 ÷	
				PER CUBIC FOOT.	·0323577	$\frac{Y}{Y-1} = 4 \qquad \frac{Y-1}{Y} = ·2504$
					·6884 = C_p	
						$L = 8467\left(\frac{T}{T_o} - 1\right)$ FOOT POUNDS

NOTE – SPEC GRAV 402 OBSERVED. SPEC GRAV ·4008 CALCULATED

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When a gas is heated two different results may be obtained, depending upon whether the gas is allowed to expand and increase its volume when heated, the pressure remaining constant, or whether the air is confined and the volume remain constant, and the pressure increasing. The amount of heat to raise the temperature of a gas 1° under these two conditions is different, therefore, the specific heat is different. The former is called—Specific heat at constant pressure, and the latter—Specific heat at constant volume.

Referring to Table 1, Figure 3, if we have a cylinder A, containing one pound of gas at atmospheric pressure, and a piston P, without weight, but having an area of one square foot, and heat the gas until the temperature has risen 1° Fah., the gas will have expanded by the small amount d, as in Figure 4, and raised the piston. This expansion is 1/460 of the original volume, at 0° Fah.

It is evident that inasmuch as the piston has raised and displaced the atmosphere, that work has been done, which must have absorbed heat in addition to that necessary to raise the temperature of the air 1°, . If the piston was fastened, as in Figure 3, the gas would have required just that less heat to raise it 1° as was required to lift the piston through the distance d = 1/460 of its volume. The amount of heat required in the first instance is called specific heat at constant pressure, and the latter at constant volume.

Specific heat of most of the gases at constant pressure has been determined by Regnault and others experimentally, and the symbol is C_p.

TABLE 3. CRUDE OIL GAS MANUFACTURED AT FRESNO CAL. BY CALIFORNIA GAS AND ELECTRIC COR JUNE 1905

1	2	3	4	5	6	7
SYMBOL	PERCENT OF VOLUME	WEIGHT PER CUBIC FOOT 32° FAH	C_p	PERCENT OF VOLUME X WEIGHT PER CU. FT.	PERCENT OF VOLUME X WEIGHT PER CU. FT. X C_p	
C_2H_4	5	·0780922	·404	·39046	·157745	$\frac{V_o P_o}{T_o} = R = \frac{144 \times 1}{\frac{.028453}{492} \times 14.7}$
CH_4	29·7	·044668	·5329	1·32640	·706420	
H	53·4	·005594	3·409	·30968	1·055700	$R = \frac{35.146 \times 144 \times 14.7}{492} = 151$
CO	5	·0780922	·2479	·39045	·096733	
CO_2	1	·122760	·217	·12276	·026577	$C_v = C_p - \frac{R}{J} = ·7724 - \frac{151}{772} = ·7724$
N	3·9	·078371	·24380	·30564	·074515	$- ·1956 = ·5768.$
O		·089180	·21751			
	100·00			2·84539	2·19775	$\frac{C_p}{C_v} = \frac{·7724}{·5768} = 1·339 = Y$
				= ·028453	·0219775 ÷	
				PER CUBIC FOOT.	·028453 =	$\frac{Y-1}{Y} = ·253 \qquad \frac{Y}{Y-1} = 3·95$
					·7724 = C_p	
						$L = 836\left(\frac{T}{T_o} - 1\right)$ FOOT LBS.

NOTE ÷ SPEC. GRAV ·353. OBSERVED. – SPEC. GRAV ·3524 CALCULATED

E.A.RIX.

TABLE 4. CRUDE OIL GAS MANUFACTURED AT HAPPY VALLEY CAL. BY CALIFORNIA GAS AND ELECTRIC COR JUNE 1905.

1	2	3	4	5	6	7
SYMBOL	PERCENT OF VOLUME	WEIGHT PER CUBIC FOOT 32° FAH.	C_p	PERCENT OF VOLUME X WEIGHT PER CU. FT.	PERCENT OF VOLUME X WEIGHT PER CU. FT. X C_p	
C_2H_4	10·3	·0780922	·404	·80435	·324957	$\frac{V_o P_o}{T_o} = R = \frac{144 \times \cdot 0374492 \times 14.7}{492}$
CH_4	26	·044668	·5929	1·161368	·688530	
H	46	·005594	3·409	·25732	·877210	$R = \frac{26.70 \times 144 \times 14.7}{492} = 114.8$
CO	6	·0780922	·2479	·46855	·116150	
CO_2	3	·1227603	·217	·36828	·073167	$C_v = C_p - \frac{R}{J} = ·6015 - \frac{114.8}{772}$
N	8·4	·078371	·24380	·65831	·160840	$= ·6015 - ·1487 = ·4528$
O	·3	·089180	·21751	·02675	·005818	
	100·00			3·74492	2·252672	$\frac{C_p}{C_v} = \frac{·6015}{·4528} = 1·328 = Y$
				= ·0374492	·0225267	
				PER CUBIC FOOT	÷ ·0374492	$\frac{Y-1}{Y} = ·247 \quad \frac{Y}{Y-1} = 4·054$
					= ·6015 = C_p	
NOTE SPEC GRAV ·464 CALCULTION						$L = 8573\left(\frac{T}{T_o} - 1\right)$ FOOT LBS
						E.A.RIX.

The amount of work done in lifting the piston through the distance d is measured the same as the work done by any piston by multiplying the pressure on the piston by the distance passed through. The area multiplied by the distance is the volume, which may be expressed by V. The distance d is 1/460 at 0° Fah., or may be expressed by $\frac{1}{T}$

Let P be the pressure, and R, the foot-pounds of work done, then

$\frac{V P}{T} = R$ and this is called the Simple Gas Equation, and about it hangs many important deductions.

R is a constant for any gas, because inasmuch as the gas expands uniformly for each 1° of heat, any volume as V_1 multiplied by its corresponding P_1 and divided by its corresponding temperature T, will equal R, or to put it algebraically,

$$\frac{V P}{T} = \frac{V_1 P_1}{T_1} = \frac{V'' P''}{T''} = R = \text{Constant}$$

R being always in foot-pounds, if we divide it by Joules equivalent 772, which is, as you know, the amount of foot-pounds equal to 1 heat unit, and which is always denoted by J, we shall have the amount of heat units that were converted into work to raise the piston, and this amount of heat, we know, must be the difference between the specific heat at the constant pressure and the specific heat at constant volume, or,

$$\frac{R}{J} = C_p - C_v$$

TABLE 5 CARBURETTED WATER GAS PURIFIED SAN FRANCISCO. GAS CO NORTH BEACH DEC. 14TH 1897

1	2	3	4	5	6	7
SYMBOL	PERCENT OF VOLUME	WEIGHT PER CUBIC FOOT 32° FAH	C_p	PERCENT OF VOLUME X WEIGHT PER CU. FT	PERCENT OF VOLUME X WEIGHT PER CU. FT. X C_p	
C_2H_4	9·2	·0780922	·404	·72842	·29427	$\frac{V_o P_o}{T_o} = R = \frac{144 \times \cdot 04671 \times 14.7}{432}$
CH_4	22·2	·044668	·5929	·99145	·58780	
H	35·1	·005594	3·409	·19610	·66850	$R = \frac{21.4 \times 144 \times 14.7}{492} = 92.02$
CO	25·2	·0780922	·2479	1·96786	·48781	
CO_2	3	·1227603	·217	·36810	·07987	$C_v = C_p - \frac{R}{J} = ·47 - \frac{92.02}{772}$
N	4·3	·078371	·24380	·38367	·09352	$= ·47 - ·1192 = ·3508$
O	·4	·089180	·21751	·03564	·00772	
	100·00			4·67124	2·21949	$\frac{C_p}{C_v} = \frac{·47}{·3508} = 1·34 = Y$
				·04671	·0221949	
				PER CUBIC FOOT	÷ ·04671	$\frac{Y-1}{Y} = ·254 \quad \frac{Y}{Y-1} = 3·97$
					= ·47 = C_p	
NOTE SPEC GRAV ·578 AT 32°						$L = 8403\left(\frac{T}{T_o} - 1\right)$ FOOT LBS
						E.A.RIX.

TABLE 6 COAL GAS MANUFACTURED AT HUDSON MASS. ANALYZED BY STATE INSPECTOR OF GAS

1	2	3	4	5	6	7
Symbol	Percent of Volume	Weight per cubic foot 32° Fah	C_p	Percent of volume × Weight per cu ft	Percent of volume × Weight per cu ft × C_p	
C_2H_4	5·31	·0780922	·404	·46151	·18644	$\frac{V_o P_o}{T_o} = R = \frac{144 \times \frac{1}{·03292} \times 14·7}{492}$
CH_4	31·31	·044668	·5929	1·69306	1·00377	
H	45·32	·005594	3·409	·25463	·86793	$R = \frac{30·4 \times 144 \times 14·7}{492} = 130·72$
CO	5·60	·0780922	·2479	·43730	·10840	
CO_2	1·07	·1227603	·217	·13128	·02847	$C_v = C_p - \frac{R}{J} = ·683 - \frac{130·72}{772} =$
N	3·84	·078371	·24380	·30094	·07118	$= ·683 - ·1699 = ·5137$
O	·15	·089180	·21751	·01337	·00230	
	100·00			3·29209	2·24303	$\frac{C_p}{C_v} = \frac{·683}{·5137} = 1·33 = Y$
				= ·03292	·02243	
				Per Cubic Foot	÷ ·03292	$\frac{Y-1}{Y} = ·248 \quad \frac{Y}{Y-1} = 4$
					= ·683 = C_p	
NOTE Spec. Grav ·408 ·						$L = 8467\left(\frac{T}{T_o} - 1\right)$ Foot Lbs

E. A. Rix

from which we have

$$C_v = C_p - \frac{R}{J}$$

an equation from which the specific heat at constant volume may be determined for any gas within the limits of its stability, and certainly within the commercial pressures you are likely to encounter.

For a perfect gas, these specific heats are practically constant; that is, they are not affected by pressure or temperature, but so far hydrogen and air appear to be nearer than any other gases. CO and CO_2, which are inferior components of illuminating gas, as it is now made, shows the greatest deviation, but not enough to render their vagaries of moment in the consideration of the power question, consequently all the following data has been calculated on the basis of the simple gas law.

$$\frac{PV}{T} = R = \text{Constant.}$$

As an example showing how to calculate the specific heat at constant volume, let us take C_2H_4. I have selected this gas because it caused me a great deal of work and nearly caused me to abandon this paper because I could not check any of the calculations by using the value assigned by Regnault and copied evidently by all others down the line.

Upon applying the simple gas equation to the Regnault value I found that it was wrong, and it will be interesting no doubt to make the calculations here, and thus make them serve the double purpose of showing how to determine the specific heat at constant volume and to point out the error.

Regnault gives the C_p of C_2H_4 to be .404, and C_v to

TABLE 7 CALIFORNIA. NATURAL GAS SUISUN CAL. DEC 20TH 1901

1	2	3	4	5	6	7
Symbol	Percent of Volume	Weight per cubic foot 32° Fah	C_p	Percent of volume × Weight per cu ft	Percent of volume × Weight per cu ft × C_p	
C_2H_4	0	·0780922	·404	·00000	0000	$\frac{V_o P_o}{T_o} = R = \frac{144 \times \frac{1}{·04566} \times 14·7}{492}$
CH_4	32·58	·044668	·5929	4·11530	2·4403	
H	2·18	·005594	3·409	·01219	0415	$R = \frac{21·3 \times 144 \times 14·7}{492} = 84·17$
CO	0	·0780922	·2479	·0000	0000	
CO_2	·6	·1227603	·217	·07362	·01597	$C_v = C_p - \frac{R}{J} = ·5664 - \frac{84·17}{772}$
N	4·44	·078371	·24380	·34796	·08481	$= ·5664 - ·122 = ·4444$
O	·2	·089180	·21751	·01783	·00387	
	100·00			4·56690	2·58645	$\frac{C_p}{C_v} = \frac{·5664}{·4444} = 1·28 = Y$
				= ·04566	·025864	
				Per Cubic Foot	÷ ·04566 =	$\frac{Y-1}{Y} = ·219 \quad \frac{Y}{Y-1} = 4·41$
					·5664 = C_p	
NOTE Spec. Grav ·566 calculated						$L = 9335\left(\frac{T}{T_o} - 1\right)$ Foot Lbs.

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be .173. The weight per cubic foot to be .0780922, or 12.8 cubic feet in one pound at 32° Fah.

If, now, one pound, or 22.30 cubic feet, be heated to 1° Fah. and allowed to expand, the simple gas equation $\frac{PV}{T^\circ} = R$ will give at 32°

$$\frac{22.39 \times 144 \times 12.8}{492} = R = 55.$$

Fifty-five foot-pounds of work has been performed by the gas in expanding against the atmosphere; to convert this into heat units we divide by Joules equivalent 772.

$$\frac{55}{772} = .07124 \text{ units of heat.}$$

Inasmuch as

$$C_v = C_p - \frac{R}{J} \text{ and } \frac{R}{J} = .07124$$

we have $C_v = .404 - .07124 = .3327$, instead of .173 as determined by Regnault. The ratio between the two specific heats forms the basis for all the calculations for the relations between pressure, volume and temperature in compressing gas, and that is why we must be particular about these specific heat factors.

$\frac{C_p}{C_v} = y$, which we shall discuss further on, and which is brought in now simply as additional proof about the figures which we have just obtained for $C_2 H_4$.

For $C_2 H_4$, using Regnault's values, we have

$$y = \frac{.404}{.173} = 2.33$$

for our values

$$y = \frac{.404}{.3327} = 1.214.$$

In reading a new book by Travers on the study of gases (page 275), he gives some very interesting calculations to show the limiting values of $\frac{C_p}{C_v}$ or y.

His conclusions are that for a monoatomic gas within the limits of the simple gas equation $\frac{PV}{T^\circ} = R$, he values of $\frac{C_p}{C_v}$ can never exceed 1.667, and the value for a diatomic gas should range about 1.4 and the polyatomic gases still less, until we reach the value of 1, where, of course, there should be no expansion work at all when heat was applied.

We can see, therefore, that the value $\frac{C_p}{C_v}$ of 2.33 from Regnault's values is an impossibility, the maximum possible value being only 1.667, and $C_2 H_4$ being the polyatomic gas, its value would be less than 1.4, all of which indicates that our figures $\frac{C_p}{C_v} = 1.214$ are approximately correct.

It will now be necessary to apply our understanding of these principles and try and determine the values of the specific heats for illuminating gas. There seems to be plenty of data about the specific heat at constant pressure for gas mixtures, but nothing about the specific heat at constant volume.

Reference is now made to the Tables 2, 3, 4, 5, 6, 7 and 8, which show the composition and heat properties of seven different gases and the methods employed in determining the weights, specific gravities and specific heats.

Column 1 is the chemical symbol for the different components.

Column 2 is the percentage by volume of the different components.

Column 3 gives reliable weights per cubic foot.

Column 4 gives the specific heat of each component gas as determined by Regnault and others.

Column 5 gives the product of the different percentages of the component gases and their weights per cubic foot, or Column 2 multiplied by Column 3. The total sum divided by 100 gives the weight of the gas per cubic foot.

Column 6 gives the product of Column 4 and Column 5 for specific heat, being a weight function. We must, in order to get the specific heat of the compound gas, take into consideration not only the percentages of the component parts, but the weights as well, and also the specific heat of each component. The sum of the products in column divided by 100, and then by the weight of one cubic foot of the compound gas, will give the specific heat at constant pressure C_p.

Column 7 gives the calculations to find the specific heat at constant volume and also R and $\frac{C_p}{C_v}$ or y for each gas, and also various factors of y which we will find useful later.

Table 9 concentrates Tables 2 to 8, so that we may study them easier.

You will note that our results cover quite a field, taking in California fuel oil gas, Massachusetts coal gas, Indiana natural gas, California natural gas, and California carburetted water gas, and after carefully studying their heat and power properties, as shown in Table 9, I have selected the fuel oil gas made in Oakland as having the best average properties for the purposes we have in view, and particularly as fuel oil gas is the one you will probably have most to deal with.

We may therefore consider our subject as having for a basis a gas with the following properties at 32° Fah

Weight per cubic foot, .0323577.

Cubic foot in one pound avoirdupois, 30.98.

Specific gravity, .4008.

$C_p = .6884.$

$C_v = .5159.$

$y = 1.334.$

$$\frac{y-1}{y} = .25.$$

$$\frac{y}{y-1} = 4.$$

$R = 133.2.$

$$L = 8467 \left(\frac{T}{T^\circ} = 1\right)$$

A cubic foot of gas varies in weight according to the altitude or pressure, and also according to the temper-

TABLE 8. AVERAGE NATURAL GAS. KENT PAGE 649 1835

1	2	3	4	5	6	7
SYMBOL	PERCENT OF VOLUME	WEIGHT PER CUBIC FOOT 32° FAH	C_p	PERCENT OF VOLUME X WEIGHT PER CU. FT.	PERCENT OF VOLUME X WEIGHT PER CU FT X C_p	
C_2H_4	.31	.0780922	.404	.02421	.00978	$\frac{V_o P_o}{T_o} = R = \frac{144 \times .045786 \times 14.7}{492}$
CH_4	32.6	.044668	.5929	4.13551	2.45190	
H	2.18	.005594	3.409	.01219	.04155	$R = \frac{21.84 \times 144 \times 14.7}{492} = 93.96$
CO	.50	.0780922	.2479	.03904	.00977	
CO_2	.26	.1227603	.217	.05642	.01223	$C_v = C_p - \frac{R}{J} = .57 - \frac{93.96}{772} =$
N	3.61	.078371	.24380	.28031	.06848	$= .57 - .122 = .448$
O	.34	.089180	.21751	.03032	.00659	
	99.80			4.57860	2.60030	$\frac{C_p}{C_v} = \frac{.57}{.448} = 1.272 = Y$
				= .045786	.026003	
				PER CUBIC FOOT	÷ .04578	$\frac{Y-1}{Y} = .214$ $\frac{Y}{Y-1} = 4.67$
					= .57 = C_p	
NOTE - HAVE FIGURED 100% INSTEAD OF 99.80% AS ABOVE.						$L = 3885\left(\frac{T}{T_o} - 1\right) = 5100$ FOOT POUNDS
						E.A.R.M.

atures. The law of this variation is expressed as follows:

Having given the weight of a gas for any temperature, or any pressure, then the weight at any other temperature or pressure will be as the ratio of absolute temperature or pressure, or

$$W' = W\frac{T}{T^\circ} \text{ or } W\frac{P}{P^\circ} \text{ where}$$

W = known weight.

T° and P° the known temperature or pressure and W' the desired weight.

For example—Our standard gas weights at sea level, or 14.7 pounds absolute pressure, and 32° Fah., .03235 pounds per cubic foot; at 20 pounds gauge, or 34.17 pounds absolute, a cubic foot would weigh $.03235 \times \frac{34.17}{14.7} = .03235 \times 2.36 = .076346$ pounds, and at 60° Fah., instead of 32° Fah., this cubic foot would weigh $.076346 \times \frac{520}{460} = .0819$ pounds. 460 being the absolute temperature of O° and 520 the absolute temperature of 60° Fah. = 460 + 60 = 520.

Altitudes are nothing more or less than pressures less than sea level, and are treated just the same as pressures above the normal atmospheric.

Thus at 5225 feet the absolute pressure is 12.044, consequently, as gas at this altitude would weigh $\frac{12.044}{14.7}$ times the weight at sea level.

For your convenience it may be well to add here that when the barometric pressure is known, the atmospheric pressure is found by multiplying the barometric pressure by .4908, or $P^\circ = B \times .4908$.

TABLE 9. PROPERTIES OF ILLUMINATING GASES. 32° FAH. JUNE 1905.

LOCATION OF WORKS	COMPOSITION BY VOLUME.							WEIGHT PER CU. FT.	SPEC. GRAV.	C_p	C_v	Y	$\frac{Y}{Y-1}$	$\frac{Y-1}{Y}$	R	L FOOT POUNDS
	C_2H_4	CH_4	H	Co	Co_2	N	O									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FRESNO	5	29.7	55.4	5	1	3.3	0	.028453	.3524	.7724	.5768	1.339	3.95	.253	151	$8364\left(\frac{T}{T_o} - 1\right)$
OAKLAND	7	28.3	51.9	5	3	4.8	0	.0323577	.4008	.6884	.5153	1.334	4.	.25	133.2	$8467\left(\frac{T}{T_o} - 1\right)$
HAPPY VALLEY	10.3	26	46	6	3	6.4	3	.0374432	.464	.6015	.4528	1.328	4.05	.247	114.8	$8573\left(\frac{T}{T_o} - 1\right)$
								NATURAL GAS.								
AVERAGE NATURAL GAS	.31	32.6	2.18	.5	.26	3.61	.34	.045786	.567	.57	.4482	1.272	4.67	.214	93.96	$3885\left(\frac{T}{T_o} - 1\right)$
CAL. NATURAL GAS SUISUN CAL. DEC 20TH 04	0	92.58	2.18	0	.6	4.44	.2	.04566	.566	.5664	.4444	1.28	4.41	.219	94.17	$3935\left(\frac{T}{T_o} - 1\right)$
								COAL GAS								
HUDSON MASS. ANALYZED BY STATE INSPECTOR.	5.91	37.31	45.52	5.6	1.87	3.84	.15	.03292	.408	.683	.5137	1.33	4.	.248	130.7	$8467\left(\frac{T}{T_o} - 1\right)$
								CARBURETTED WATER GAS PURIFIED								
NORTH BEACH DEC 14TH 1897.	9.2	22.2	35.1	25.2	3.	4.3	.4	.04671	.578	.47	.3508	1.34	3.97	.254	32.02	$8403\left(\frac{T}{T_o} - 1\right)$ E.A.R.M.

For example—When the barometric is 29.92 the atmospheric pressurre is 29.92 × 4908, or 14,7, the normal sea level pressure.

To find the atmospheric pressure when the altitude in feet is given, we have

$$P^\circ = 14.72 - \frac{57000\,N - N^2}{100,000,000}$$ in which

N = altitude in feet.

For example—To find the atmospheric pressure at 10,000 feet we have

$$P^\circ = 14.72\,\frac{57,000 \times 10,000 \times (10,000)^2}{100,000,000}$$ or

$P^\circ = 14.72 - 4.7 = 10.02$, the atmospheric pressure required.

The foregoing rules will be all that is necessary to calculate all variations of weights due to pressure, altitude or temperature, and relative volumes follow exactly the same laws as relative weights.

For convenience in many calculations Table 10 is given herewith, showing the pressure ratios, or $\frac{P}{P^\circ}$ for every pound from 1 to 110, and the volumes ratios will be inversely as the pressure ratios and consequently the reciprocal of the figures on the table.

This might be called a table showing also the rates of Isothermal compression or expansion or Marriotte's law, the general formula for which is:

$P^\circ V^\circ = P V$ = Constant, or in other words, the product of any pressure by its volume is always equal to the product of any other pressure by its volume, and this rule will be found useful in determining the contents of receivers, etc. It must always be remembered that in using these rules all temperatures must be alike, or corrections made according to the rules just given.

There are two methods of compressing any gas.

First—Where the temperature remains unchanged during compression. This is called Isothermal compression and is the ideal method never realized in practice.

Second—Adiabatic compression, which is the kind we meet in practice where the heat developed by compression expands, the air being compressed until it follows a different law from Marriotte.

While Isothermal compression is not practical, it is necessary to know about it and how to make the calculations concerning it.

We have found that the volume ratios are inversely as the absolute pressure ratios in Isothermal compression. Consequently if the pressure ratios are 1, 2, 3 and 4, the corresponding volumes will be 1, ½, ⅓, ¼. To show this graphically—refer to Table 1, Figure 1.

Let $A\,B$ be the line of 0 pressure or the perfect vacuum line. $C\,D$ the intake line and we erect pressures ordinates $G\,H = 2 \times D\,B$ at a point H equal to ½, $A\,B$ and $L\,J = 3 \times B\,D$ at a point $J = ⅓\ A\,B$ and $E\,K = 4 \times B\,D$ at a point $K = ¼$ of $A\,B$ counting all volumes from $F\,B$ or the end of the piston stroke.

If we join the points $C\,G\,I\,E$ in a curved line, it will be the Isothermal or logarithmic curve and it will be noted that the area

$E\,F\,B\,K = 4 \times ¼ = 1$
$I\,L\,B\,J = 3 \times ⅓ = 1$
$G\,M\,B\,H = 2 \times ½ = 1$
$C\,D\,B\,A = 1 \times 1$ or 1

As found before, $P^\circ\ V^\circ = P'\ V'$ = Constant, and the figure represents the ideal indicator card for Isothermal compression for four compressions, counting from 0, and the above method will always be proper to lay out an Isothermal curve, no matter what the intake pressure may be.

To find the work of compression and delivery Isothermally

$P^\circ\ V^\circ$ hyp. log $\frac{P}{P^\circ}$ in foot pounds in which

P° = Initial pressure absolute.
V° = Initial Volume
P = Final pressure
L = Work required.

In all of our calculations V° will be taken as one cubic foot.

For Example—How many foot-pounds of work is required to compress 1 cubic foot of gas at sea level to eighty pounds gauge pressure.

For sea level P° per square foot = 14.7 × 144 = 2116.8 pounds. Then

$$L = 2116.8 \text{ hyp. log. } \frac{P}{P^\circ}$$

Consulting Table 10 we find

$\frac{P}{P^\circ}$ for 80 pounds gauge = 6.442 the hyperbolic logarithm of which is 1.863.

Substituting, we have

$L = 2116.8 \times 1.863 = 3943$ foot-pounds.

If a table of hyperbolic logarithms is not at hand, it would be well to remember that hyp. log. = common log. × 2.3026.

The hp. required for above work will be $\frac{3945}{33000} = .1195\ HP$

To find the $M\,E\,P$ of Isothermal compression,

$M\,E\,P = P^\circ$ hyp. log. $\frac{P}{P^\circ}$, using the quantities in the previous example we have $M\,E\,P = 14.7 \times 1.863 = 27.38$ pounds. We know that HP. = $\frac{M\,E\,P \times V}{33000}$ and for one cubic foot $V = 1 \times 144$. Consequently, using the last example,

$$HP = \frac{27.38 \times 1 \times 144}{33000} = .1195,$$ the same result as before. $\frac{1 \times 144}{33000} = .00436$. Consequently a short and convenient formula would be for Isothermal compression $HP = .00436 \times M\,E\,P$.

It will be noted that none of the physical properties of gases enter into the above equations, consequently we must conclude that it takes the same power to compress one cubic foot of any gas Isothermally to the same pressure, provided the ratios of pressures are the same.

ADIABATIC COMPRESSION.

We have before stated that Isothermal compression is ideal, and not realized in practice. All of the work expended in compressing a gas is converted into heat instantly, and this increases both the temperature and the volume of the gas during compression, so that, instead of having a relation between pressure and volume ($P_o V_o = P V$ = Constant), such as we found in Isothermal compression, we now have a relation $P_o V_o^y = P V^y$ = Constant, or in other words, the gamma powers of each volume, multiplied by its corresponding pressure, is Constant. This is the equation of the Adiabatic curve. y is the same that we found to be the ratio between the specific heat at constant pressure and that at constant volume. This relation can perhaps be fastened a little easier in the mind by remembering that the equation of the Isothermal curve represents the law of Marriotte and the equation of the adiabatic curve represents the Exponential law of Marriotte.

Inasmuch as the power to compress a gas is measured practically by the indicator diagram, and this in turn is compared to the adiabatic curve which is theoretical curve of compression, and inasmuch as we depend upon the value of y to construct this curve, it will be at once seen why we were to particular to discover the relation $\frac{C^p}{C^v} = y$. Now if $P_o V_o^y = P V^y$ and from the single gas equation $\frac{V^o P^o}{T^o} = \frac{V P}{T} = R$, by combining these we have all the adiabatic relations between volume pressure and temperature as follows:

$$\frac{P}{P^o} = \left(\frac{V^o}{V}\right)^y = \left(\frac{T}{T_o}\right)^{\frac{y}{y-1}}$$

$$\frac{V}{V_o} = \left(\frac{P^o}{P}\right)^{\frac{1}{y}} = \left(\frac{T^o}{T}\right)^{\frac{1}{y-1}}$$

$$\frac{T}{T^o} = \left(\frac{V^o}{V}\right)^{y-1} = \left(\frac{P}{P^o}\right)^{\frac{y-1}{y}}$$

It will always be necessary to use the above formulæ in making calculations for pressures, temperatures and volumes, or for power to compress any gas which varies far enough from the standard we have selected to make it necessary, but there is no doubt that for all practical purposes, at least for the present, Table 11, which is calculated for our standard gas, will give the proper values for rapidly and easily calculating any problems connected with compressing illuminating gas.

All reference to expansion is purposely omitted, because gas will probably never be used for expansion work in an engine as air is used

Assuming that all may not be familiar with just how to arrive at the results as indicated in Table 11, let us take a ratio of $\frac{P}{P^o} = 2$ corresponding to 14.7 pounds gauge pressure and discover what are the values of $\frac{V}{V^o}$ and $\frac{T}{T^o}$ we have $\frac{V}{V^o} = \left(\frac{P^o}{P}\right)^{\frac{1}{y}}$ y we have already decided from our standard gas to be 1.334.

Therefore, $\frac{1}{y} = \frac{1}{1.334} = .749$ $\frac{V}{V^o} = \left(\frac{P^o}{P}\right)^{.749}$ or since

$\frac{P^o}{P} = \frac{1}{2}$ or .5 we have

$\frac{V}{V^o} = .5^{.749}$ or

Log $\frac{V}{V^o}$ = log .5 × .749

Log .5 = 1.6989 × .749 = 1.77447 = log $\frac{V}{V^o}$ giving value of $\frac{V}{V^o} = .5949$ and $\frac{V^o}{V}$ will be reciprocal of $\frac{V}{V^o}$ or 1.681.

To find the ratio of temperature for this same rate of compression, we have $\frac{T}{T^o} = \left(\frac{P}{P^o}\right)^{\frac{y-1}{y}}$ $\frac{y-1}{y} = .25$.

PRESSURE RATIOS JULY 1905 TABLE 10

Gauge	$\frac{p}{po}$	Gauge	$\frac{p}{po}$	Gauge	$\frac{p}{po}$
1	1·068027	38	3·585026	75	6·102025
2	1·136054	39	3·653053	76	6·170052
3	1·204081	40	3·721080	77	6·238079
4	1·272108	41	3·789107	78	6·306106
5	1·340135	42	3·857134	79	6·374133
6	1·408162	43	3·925161	80	6·442160
7	1·476189	44	3·993188	81	6·510187
8	1·544216	45	4·061215	82	6·578134
9	1·612243	46	4·129242	83	6·646241
10	1·680270	47	4·197269	84	6·714268
11	1·748297	48	4·265296	85	6·782295
12	1·816324	49	4·333323	86	6·850322
13	1·884351	50	4·401350	87	6·918349
14	1·952378	51	4·469377	88	6·986376
15	2·020405	52	4·537404	89	7·054403
16	2·088432	53	4·605431	90	7·122430
17	2·156459	54	4·673458	91	7·190457
18	2·224486	55	4·741485	92	7·258484
19	2·292513	56	4·809512	93	7·326511
20	2·360540	57	4·877539	94	7·394538
21	2·428567	58	4·945566	95	7·462565
22	2·496594	59	5·013593	96	7·530592
23	2·564621	60	5·081620	97	7·598619
24	2·632648	61	5·149647	98	7·666646
25	2·700675	62	5·217674	99	7·734673
26	2·768602	63	5·285701	100	7·802700
27	2·836729	64	5·353728	101	7·870727
28	2·904756	65	5·421755	102	7·938754
29	2·972783	66	5·489782	103	8·006781
30	3·040810	67	5·557809	104	8·074980
31	3·108837	68	5·625836	105	8·142835
32	3·176864	69	5·693863	106	8·210862
33	3·244891	70	5·761890	107	8·278889
34	3·312918	71	5·829917	108	8·346916
35	3·380945	72	5·897944	109	8·414943
36	3·448972	73	5·965971	110	8·482970
37	3·516999	74	6·033999		

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Hence:

$$\text{Log}\ \frac{T}{T^\circ} = .25 \log.\ \frac{P}{P^\circ}$$

$$\text{Log.}\ \frac{P}{P^\circ} = .301 \times .25 = .07525 = \text{Log.}\ \frac{T}{T^\circ}$$

$$\frac{T}{T^\circ} = .1892$$

$T = 520 \times 1.1892 = 618°$ absolute or 158° Fah.

If $T^\circ = 60°$ Fah. We have then

$$\frac{P}{P^\circ} = 2 \qquad \frac{V^\circ}{V} = 1.681 \qquad \frac{V}{V^\circ} = .5949$$

$$\frac{T}{T^\circ} = 1.1892 \quad T = 158°$$

Air under the same conditions gives

$$\frac{P}{P^\circ} = 2 \qquad \frac{V^\circ}{V} = 1.6349 \qquad \frac{V}{V^\circ} = .6117$$

$$\frac{T}{T^\circ} = 1.2226 \quad T = 175° \text{ Fah}$$

TABLE II. ADIABATIC TABLE FOR GAS. JULY 1905.

$\frac{P}{P_o}$	$\frac{T}{T_o}$		$\frac{T}{T_o} - 1$	$\frac{V}{V_o}$	
	NUMBER	DIFF.		NUMBER	DIFF.
1·2	1·0466	412	·0466	·8063	300
1·4	1·0878	369	·0878	·7763	733
1·6	1·1247	336	·1247	·7030	534
1·8	1·1583	309	·1583	·6436	488
2·	1·1892	287	·1892	·5948	410
2·2	1·2179	268	·2179	·5538	352
2·4	1·2447	251	·2447	·5186	301
2·6	1·2698	268	·2698	·4885	264
2·8	1·2966	135	·2966	·4621	233
3·	1·3161	214	·3161	·4388	207
3·2	1·3375	204	·3375	·4181	186
3·4	1·3579	195	·3579	·3995	168
3·6	1·3774	186	·3774	·3827	152
3·8	1·3962	180	·3962	·3675	139
4·	1·4142	173	·4142	·3536	126
4·2	1·4315	168	·4315	·3410	117
4·4	1·4483	162	·4483	·3293	108
4·6	1·4645	157	·4645	·3185	99
4·8	1·4802	152	·4802	·3086	94
5·	1·4954	697	·4954	·2992	383
6	1·5651	615	·5651	·2609	284
7	1·6266	552	·6266	·2325	222
8	1·6818	503	·6818	·2103	177
9	1·7321	462	·7321	·1926	147
10	1·7783		·7783	·1779	

E.A.R.

These examples will serve to show how this Table 11 was calculated. A few examples will show its use.

Problem—To find the final temperature due to adiabatic compression.

Opposite $\frac{P}{P^\circ}$ and under the headline $\frac{T}{T^\circ}$ will be found the ratio of absolute temperatures.

Example—What is the final temperature due to 14.7 pounds gauge pressure at sea level and 60° Fah.

$\frac{P}{P_o} = \frac{29.4}{14.7} =$. Then $\frac{T}{T^\circ} = 1.1892$, or $.520 \times 1.1892 = 618°$ abs. or 158° Fah.

If the initial temperature has been 100° then $560 \times 1.1892 = 666°$ Fah.

It is readily noted from this that the higher the initial temperature, the higher the final temperature, and it will also be noted that while there is a difference of 40° between the initial temperature, there is a difference to 48° between the final temperatures; a difference of 8°.

Inasmuch as the temperature developed during compression is at the expense of power, it is evident that it takes more power to compress the same weight of gas at 100° Fah. then at 60° Fah. to the same pressure, all other conditions being similar.

It is an axiom, therefore, that the cost of power for compressing gas will be the least when the initial temperature is the lowest, and it will be shown later on that cooling before compression will effect a considerable saving, if the gas to be compressed is drawn from the holder exposed to the sun, provided, of course, that cooling water may be had at a small expenditure of power.

Problem—To find the volume immediately after compression.

Consult Table 11, and under the heading $\frac{V}{V^\circ}$ and opposite the pressure ratio $\frac{P}{P^\circ}$ the proper value will be found; and it must always be remembered that these values of temperature and volumes assume no radiation of heat whatever, for when the heat generated by compression has radiated the temperatures and volumes are as calculated Isothermally.

Please note that $\frac{V}{V^\circ}$ is measured from the end of the stroke. The difference given in Table 11 will enable greater or lesser values of $\frac{P}{P^\circ}$ to be conveniently determined by simple rules of proportion.

From this Table the adiabatic curve can be readily drawn.

Refer to Table 1, Figure 2.

Let $A\ B$ be the intake line and $C\ D$ the line of o pressure, these lines representing the piston stroke. Divide $A\ B$ into a decimal scale, beginning at B erect $F\ D$ at the end of the stroke and divide it into equal values of $B\ D$ and $B\ D$ may be the value at sea level oa an altitude or it may be any intake pressure whatever, these rules will always apply. These values of $B\ D$ may be sub-

divided into five parts, where special accuracy is requied, and their values will also be found in Table 11.

$D\ H$ representing a ratio of $\frac{P}{P^0} = 2$, the corresponding value of $\frac{V}{V^0}$ will be found in Table 11 to be .5948, and laying off the value the point S will be found.

Similarly at G representing $\frac{P}{P^0} = 3$ we find $\frac{V}{V^0} = .4388$, and laying this off we find that the point M. And then F representing $\frac{P}{P^0}$ = has a value for $\frac{V}{V^0}$ of .3536, and we lay off this value and find point J. Joining the point $J\ M\ S\ A$ we develope the adiabatic curve, and the shape of this curve will depend upon the length of the card, the value of $\frac{C_p}{C_v}$ or y. The equation of the curve is $P\ V^y = P'\ V'^y$ or referring to the diagram.

$$MO \times (MG)^y = JL \times (JF)^y$$

T is the final absolute temperature.

V^0 is the volume at P^0.

V is the volume at P.

$P'\ V'\ T'$ are intermediate pressures, temperatures and volumes.

L is the work expressed in foot-pounds.

$H\ P$ is horsepower.

$M\ E\ P$ is mean effective pressure, which is always gauge pressure.

W is the weight of a unit volume or one cubic foot of our standard gas at 60° Fah. and at sea level, with an absolute pressure of 14.7 lbs. per square inch, or 2116.8 pounds per square foot, and equals .03063 pounds avoirdupois.

J is Joules' equivalent taken at 772 foot-pounds.

C^p is the specific heat at constant pressure = .6884.

C^v is the specific heat at constant volume = .5159.

y is $\frac{C^p}{C^v} = 1.334$.

TABLE 12 LOSS OF PRESSURE CAUSED BY FRICTION OF COMPRESSED GAS IN PIPES JULY 1905 E.A.RIX

EQUIVILANT VOLUME IN CU.FT. OF FREE AIR PER MIN. PASSING THROUGH PIPE.	SIZE OF PIPE																		
	1	1¼	1½	2	2½	3	3½	4	5	6	7	8	9	10	12	14	16	18	20
	$P_1^2 - P_2^2$ = DIFFERENCE IN SQUARES OF INITIAL AND FINAL ABSOLUTE PRESSURE, PER 100 FEET OF PIPE																		
50	90	20.52	12.	2.85															
75	201	53.10	27.72	6.90															
100	360	118.2	47.4	11.28	5.69														
150	810	265.8	106.8	25.32	12.28	5.30													
200	1440	472.8	189.6	45.9	14.76	9.24	1.62	1.44											
250	2250	738.	296.4	70.2	23.10	9.84	4.26	2.16											
300	3240	1062.	426.6	100.9	33.24	13.32	6.18	3.18											
400	5760	1890.	757.8	180.	58.38	23.70	10.98	5.64	1.86										
500	9000	2952.	1186.8	282.	92.4	37.2	17.10	8.76	2.88										
600	12960	4260.	1707.	405.	132.6	53.4	24.6	12.6	4.14										
800		7440.	3042.	720.	236.4	92.4	43.8	22.8	7.38	2.96									
1000		11760.	4740.	1128.	369.	149.2	68.4	35.04	11.52	4.62	1.65								
1500		26400.	10680.	2532.	828.	333.	153.	78.2	25.32	10.44	4.90								
2000			18960.	4500.	1476.	594.	273.	140.4	46.2	18.54	8.52	4.36							
3000			42600.	10080.	3324.	1332.	618.	315.6	103.8	41.01	19.26	9.90	5.49						
4000				18000.	5898.	2370.	1092.	562.2	184.5	74.4	34.2	17.58	9.72	5.76					
5000				28200.	9300.	3708.	1710.	876.	288.	115.8	53.4	27.42	15.24	9.0	3.62				
6000				40800.	13380.	5340.	2460.	1260.	414.6	166.8	76.8	39.6	21.9	12.96	5.22				
8000					23760.	9460.	4380.	2250.	736.	296.4	136.8	70.2	39.3	23.10	9.24	4.26			
10000					37260.	14760.	6840.	3510.	1152.	462.6	213.6	109.8	61.38	36.	14.46	6.72	3.42		
15000						33000.	15300.	7908.	2532.	1044.	480.6	247.2	136.8	81.	32.46	16.0	7.74	4.26	
20000						58800.	27360.	14100.	4614.	1854.	853.	438.6	243.6	144.	57.96	26.7	13.8	7.62	4.5
26000							42600.	21900.	7200.	2870.	1320.	678.	381.	225.	90.	42.	21.6	11.88	7.02
30000								34800.	10980.	4470.	1980.	990.	558.	324.	130.2	60.	30.9	17.1	10.08
35000								47400.	14400.	5700.	2640.	1350.	750.	441.	177.	82.2	42.0	23.4	13.5
40000								86400.	18420.	7440.	3420.	1770.	978.	576.	231.6	106.8	54.9	30.3	18.0
50000									28800.	11580.	5340.	2760.	1524.	900.	361.8	166.	85.8	47.7	28.2
60000									42600.	16680.	7680.	3960.	2196.	1296.	522.	240.4	123.	68.4	40.2
80000										29700.	13680.	7080.	3900.	2310.	924.	429.	219.	122.4	72.0
100000										46260.	21360.	11040.	6120.	3600.	1452.	672.	343.	190.2	112.8.

Problem—To determine the power to compress a gas adiabatically.

All that precedes this subject has been necessary to its proper understanding, and while possible the various symbols are well remembered, it will probably be better to group them together, so that they may be readily referred to.

P^0 is always the lesser absolute pressure, and consequently the intake pressure in compression. We shall take this as 14.7 at sea level, for the 4-inch water pressure of the gas will not fill the cylinder at any greater than atmospheric pressure. P is the final absolute pressure.

T^0 is the initial absolute pressure, and unless otherwise specified is taken at 60° Fah., or 520° absolute. That temperature being the probable temperature of the gas mains.

$$\frac{y}{y-1} = 4. \quad \frac{y-1}{y} = .25 \quad \frac{1}{y} = .75$$

$J\ C^p = 772 \times .6884 = 531.45$ foot-pounds.

These two values are Joules' equivalent for 1 lb. of gas.

$J\ W\ C^p = 531.45 \times .03063 = 16.28$ foot-pounds = Joules' equivalent for 1 cubic foot of gas.

$$J\ W\ C^p\ T^0 = 16.28 \times 520 = 8465 \text{ foot-pounds.}$$

$$\frac{y}{y-1} \times P^0\ V^0 = 4 \times 144 \times 1 \times 14.7 = 8465. =$$

the intrinsic energy of 1 cubic foot of gas at 60° Fah., or to reduce those values of foot-pounds to horsepower, we have

$$J\ W\ C^p\ T^0 = \frac{8465}{33000} = .2564\ H\ P$$

$$\frac{y}{y-1}\ P^0\ V^0 = \frac{8465}{33000} = .2564\ H\ P$$

All of these foregoing quantities are constants to be used in determining the power to compress gas, and as we have said before, are all based on a quantity of 1 cubic foot of our standard gas at sea level and 60° Fah.

We mentioned at the beginning of this paper that the power to compress any gas might be expressed by the general formula

$L = J\,W\,C^p\,(T - T^o)$, or to put it in another form,

$$L = J\,W\,C^p\,T^o\left(\frac{T}{T^o} - 1\right)$$

You now at once recognize the prefix $J\,W\,C^p\,T^o$ as the one for which we have found a value of 8465 foot-pounds. Therefore, for our standard gas we have

$$L = 8465\left(\frac{T}{T^o} - 1\right)$$ which is a practical formula.

You also recognize that $\frac{T}{T^o}$ is all you need solve, and these values are all given in Table 11 for the various values of $\frac{P}{P^o}$. We can now understand our first problem.

MEAN EFFECTIVE PRESSURES.

It will be found that inasmuch as we learn from an indicator what our gas compressor is doing, and inasmuch as $M\,E\,P$ pressures are quickly determined by a planimeter from an indicator card, that to become familiar with what the $M\,E\,P$ should be and compare it with what the compressor is doing is the best practical way of dealing with the subject.

We found that

$$L = J\,W\,C^p\,T^o\left(\frac{T}{T^o} - 1\right)$$ and that

$$J\,W\,C^p\,T^o = \frac{y}{y-1}\,P^o V^o$$, therefore

$$L = \frac{y}{y-1}\,P^o\,V^o\left(\frac{T}{T^o} - 1\right)$$

L must always equal $M\,E\,P \times V^o$, we have

$$M\,E\,P \times V^o = \frac{y}{y-1}\,P^o\,V^o\left(\frac{T}{T^o} - 1\right)$$ or

TABLE 13. PRESSURES AND SQUARES OF PRESSURES. JULY 1905 E.A.R.IX

GAUGE PRESSURE	ABSOLUTE PRESSURE	SQ. OF ABSOLUTE PRESSURE	GAUGE PRESSURE	ABSOLUTE PRESSURE	SQ. OF ABSOLUTE PRESSURE	GAUGE PRESSURE	ABSOLUTE PRESSURE	SQ. OF ABSOLUTE PRESSURE	GAUGE PRESSURE	ABSOLUTE PRESSURE	SQ. OF ABSOLUTE PRESSURE
0	14·7	216									
2	16·7	279									
4	18·7	350									
6	20·7	428									
8	22·7	515									
10	24·7	610	56	70·7	4998	105	119·7	14328	240	254·7	64853
12	26·7	713	58	72·7	5285	110	124·7	15550	250	264·7	70055
14	28·7	824	60	74·7	5580	115	129·7	16822	260	274·7	75450
16	30·7	942	62	76·7	5883	120	134·7	18144	270	284·7	81050
18	32·7	1069	64	78·7	6194	125	139·7	19516	280	294·7	86845
20	34·7	1204	66	80·7	6512	130	144·7	20938	290	304·7	92840
22	36·7	1347	68	82·7	6839	135	149·7	22410	300	314·7	99040
24	38·7	1498	70	84·7	7174	140	154·7	23932	325	339·7	115400
26	40·7	1656	72	86·7	7517	145	159·7	25504	350	364·7	132940
28	42·7	1823	74	88·7	7868	150	164·7	27125	375	389·7	151850
30	44·7	1998	76	90·7	8226	155	169·7	28796	400	414·7	181950
32	46·7	2180	78	92·7	8592	160	174·7	30500	425	439·7	193300
34	48·7	2372	80	94·7	8968	165	179·7	32290	450	464·7	215925
36	50·7	2570	82	96·7	9351	170	184·7	34100	475	489·7	239790
38	52·7	2777	84	98·7	9742	175	189·7	35980	500	514·7	264900
40	54·7	2992	86	100·7	10140	180	194·7	37905	550	564·7	318800
42	56·7	3215	88	102·7	10547	185	199·7	39875	600	614·7	378300
44	58·7	3446	90	104·7	10962	190	204·7	41900	650	664·7	441800
46	60·7	3684	92	106·7	11385	195	209·7	43970	700	714·7	510800
48	62·7	3931	94	108·7	11819	200	214·7	46090	750	764·7	584400
50	64·7	4186	96	110·7	12254	210	224·7	50430	800	814·7	663750
52	66·7	4449	98	112·7	12701	220	234·7	55060	900	914·7	836700
54	68·7	4720	100	114·7	13159	230	244·7	59960	1000	1014·7	1029650

How many foot-pounds are necessary to compress 1 cu. ft. of our standard gas to 14.7 pounds gauge pressure?

$\frac{P}{P^o} = \frac{294}{14.7} = 2$. Consulting Table 11 we find $\frac{T}{T^o} - 1 = .1892$ and $8465 \times .1892 = 1601.57$ foot-pounds, and the same method may be applied for all pressures.

If we use the value of $J\,W\,C^p\,T^o$ in horsepower, we we have $HP = .2564\left(\frac{T}{T^o} - 1\right)$ a perfectly practical formula for 1 cu. ft. of our standard gas at 60° Fah. and at sea level.

Our previous example would then be rendered:

$L = .2564 \times .1892 = .0485$ hp. for 1 cu. ft. compressed to 14.7 lbs gauge. At 80 lbs. gauge pressure.

$\frac{P}{P^o} = 6.442$ and $\frac{T}{T^o} = 1.593$

$HP = .2564 \times .593 = .1520$ hp. per cu. ft., or 15.20 HP per 100.

$$M\,E\,P = \frac{y}{y-1}\,P^o\left(\frac{T}{T^o} - 1\right)$$ and since

$\frac{y}{y-1} = 4$, we have for our standard gas

$$M\,E\,P = 4\,P^o\left(\frac{T}{T^o} - 1\right)$$

Take 80 lbs. gauge pressure.

$\frac{T}{T^o} - 1 = .593$ as determined in a former example by Table 11.

$P^o = 14.7$

$M\,E\,P = 4 \times .593 \times 14.7 = 34.86$ lbs. per sq. in. For our standard gas for one cu. ft.

$$M\,E\,P = 4 \times 14.7\left(\frac{T}{T^o} - 1\right) = 58.8\left(\frac{T}{T^o} - 1\right)$$

$$HP = \frac{144 \times 1 \times M\,E\,P}{33000} = .00436 \times M\,E\,P$$, or

$$HP = .00436 \times 58.8\left(\frac{T}{T^o} - 1\right) = 2564\left(\frac{T}{T^o} - 1\right)$$

the same result we obtained in a former example.

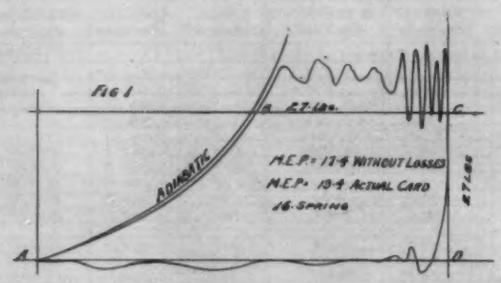
INITIAL TEMPERATURES.

The general expression for the work of compression being

$$L = \frac{y}{y-1} P^0 V^0 \left(\frac{T}{T^0} - 1\right)$$

it is evident that so long as $\frac{T}{T^0}$ remains constant, the power to compress one cubic foot of the same gas is constant, but inasmuch as the temperature of the mains is practically constant and about 60° Fah., if our initial temperature from the holder should happen for any reason to be 100° Fah., as it was entering the compressor, it is evident that the compressor must make an extra number of revolutions to deliver a fixed quantity into the mains at 60° Fah. than it would if the mains were the same temperature as the gas in the holder, and the ratio would be as the absolute temperature or $\frac{560}{520}$, or 8 per cent. additional. In a plant where 250 horsepower is used in compressing the gas, this would mean a saving of 20 horsepower. By passing the gas through a cooler before it reached the compressor would correct the loss. Inasmuch as little water is required for this, and the water is in no wise impaired for other purposes, that this cooling could always be done. *Vice versa*, if the temperature of the holder was lower than the mains, as in winter, there would be a corresponding gain and some of the otherwise lost heat of compression would be utilized in expanding the gas to a temperature corresponding to the main. In the long run, the gain might balance the loss, if no cooling were done, but it seems a business proposition to save where possible, especially where it costs little or nothing.

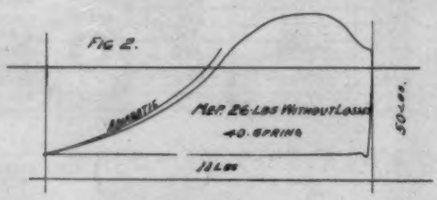
TABLE 14 INDICATOR CARDS FROM GAS COMPRESSORS. JULY 1905



$M.E.P. = \frac{Y}{Y-1} P^0 \left(\frac{T}{T^0} - 1\right)$

= 3.35 X 14.7 X .3028 = 17.58 ADIABATIC

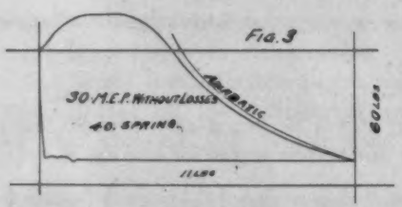
CRUDE OIL GAS FRESNO. CAL.



$M.E.P. = \frac{Y}{Y-1} P^0 \left(\frac{T}{T^0} - 1\right)$

= 4.76 X 25.7 X .219 = 26.30 ADIABATIC

NATURAL GAS. ANDERSON IND



$M.E.P. = \frac{Y}{Y-1} P^0 \left(\frac{T}{T^0} - 1\right)$

= 4.67 X 25.7 X .257 = 30.85 ADIABATIC

NATURAL GAS ANDERSON IND.

E.A.RIX.

TWO STAGE COMPRESSION.

If we consider the general equation for the work performed in compressing any gas,

$$L = J W C^p (T - T^0)$$

we note that the only variable is T, the final temperature, if our initial temperature remains the same. In other words, the difference between the initial and final temperature determines always the power expended in a compressor, just as it does the power given out by any heat engine. It is evident, then, that the lower we keep the final temperature the less power it takes. Water jacketing the cylinders accomplishes but little, probably from 3 to 5 per cent., for the reason that gases being such poor heat conductors that, while they are rapidly drawn in and pushed out of the compressing cylinder, there is not the time for the heat to radiate through the cylinder walls, and only the portion immediately in contact with the cool cylinder walls suffers any reduction of temperature. The water jacket keeps the cylinder walls cool so that lubrication is effective and is valuable for that reason principally.

Practically speaking, the compression is adiabatic, or even greater because the pressure in the cylinder is always greater than the receiver on account of the work expended in forcing the work through the valve openings, and this extra heat generated overruns the adiabatic temperature corresponding to the receiver pressure.

The water jacket being ineffective, the device of stage compression was inaugurated, where, after the gas was compressed to a portion of the final pressure in a cylinder, it was discharged into an intercooler, its temperature reduced to the initial and then compressed by a smaller cylinder to the final pressure. The work was found to be a minimum when the final temperature of each stage was the same. In a cross compound compressor this gives equal strains on the working parts on each side, and is an ideal situation.

If we represent the initial pressure by P^0 and the final by P', and volumes and temperatures similarly, we shall have, using our general formula for work expended,

$$L = \frac{y}{y-1} P^0 V^0 \left(\frac{T}{T^0} - 1\right) \text{ for first stage and}$$

$$L' = \frac{y}{y-1} P V \left(\frac{T'}{T} - 1\right) \text{ for second stage.}$$

We know that before compression $P^0\ V^0$ must equal $P\ V$, consequently if L is desired to equal L', we must have

$$\left(\frac{T}{T^0} - 1\right) = \left(\frac{T'}{T} - 1\right) \text{or}$$

$$\frac{T}{T^0} = \frac{T'}{T}$$

$$\frac{T}{T^0} = \left(\frac{P}{P^0}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T'}{T} = \left(\frac{P'}{P}\right)^{\frac{\gamma-1}{\gamma}}, \text{ or reducing}$$

$$\frac{T}{P^0} = \frac{P'}{P} \text{ or } P^1 = P^0\ P' \text{ or } P = \sqrt{P^0\ P'}$$

In other words, to make the work in two stages equal, and to have the work a minimum, P, the intermediate pressure, must be a mean proportional between the initial and the final pressure, the volumes and the piston areas must follow the same law, since we naturally make make the strokes alike.

For an example, let us take 80 lbs. final gauge pressure:

$P = \sqrt{P^0\ P'}$ or $\sqrt{14.7 \times 94.7} = 37.31$ absolute 22.61 gauge pressure. This makes

$$\frac{P^0}{P} = \frac{37.31}{14.7} = 2.54, \text{ and}$$

$$\frac{P'}{P} = \frac{94.7}{37.31} = 2.54$$

and inasmuch as these pressure ratios are the same, the work expended on each stage will be the same and the piston ratio will be 2.54 also.

We found for the standard gas that

$$H\ P = .2564\left(\frac{T}{T^0} - 1\right)$$

Referring to Table 11, we find when

$$\frac{P}{P^0} = 2.54, \text{ that } \frac{T}{T^0}\ 1.2624$$

Then $H\ P = .2564 \times .2624 = .06727$ for each stage and for both stages, $2 \times .06727 = .13454\ H\ P$.

It will be remembered that we calculated the single stage $H\ P$ for 80 lbs. in a former example as .1520. We have then 13.45 $H\ P$ per 100 cu. ft. against 15.10 $H\ P$, a saving of 13 per cent. in power.

If the maintaining of a low temperature is any advantage in gas compression, we have a temperature of 366° Fah. in the single stage compression against 195° Fah. in the two stage, a remarkable difference. Suppose now that we have a cylinder having an area of 100 sq. inches, when we compress to 80 lbs. single stage the maximum strain is 8000 lbs., if the compressor is cross-compound, and 4522 lbs. if the compressor is a tandem compound, a remarkable difference, tending to show that we can build the compressor very much lighter for the same work.

Another point in favor of the two-stage compressor, it has a greater volumetric efficiency. A piston never delivers from a cylinder an amount of gas equal to its isplacement, because clearance spaces are filled with gas at the discharge pressure, which expands in the return stroke of the piston and occupies more or less space according to the ratio of compression and the amount of clearance. The greater the temperature of compression, the hotter the piston and heads and valves get, and the less weight of gas enters the cylinder on account of its expansion. There are other losses which need not be mentioned here, but these two are sufficient to make the volumetric efficiency of single stage compressors at 80 lbs. average about 75 per cent.

It will be readily seen that the initial cylinder of a two stage machine at 80 lbs. will have its clearance losses divided by 2.54, because that will be the relative ratio of pressures and the temperature losses in proportion to $\frac{195}{366}$ because that is the temperature ratio.

These combined will make the average two stage compressor good for 90 per cent. volumetric efficiency—in other words, 15 per cent. better than a single stage. One can, therefore, afford to pay at least 15 per cent. more for a two stage machine than for a single stage machine, the intake cylinders being the same size, and this extra 15 per cent. will nearly, or sometimes quite, pay for the difference in price.

It is evident from the calculations we have made that the efficiency of a two stage machine over the single stage increases directly as the pressure ratios increase, and inasmuch as altitude increases pressure ratios, it is evident that the higher the altitude the more urgent becomes the necessity for using the two stage machines, and at altitudes above 3000 feet it is practically imperative.

Theoretically, an infinite number of stages would give isothermal compression, but practically the losses involved in driving the gas through too many cylinders and valves would offset this gain, and we can consider that two stages will probably be the limit for all ordinary purposes.

ALTITUDE COMPRESSION.

We found that it took the same power to compress one cubic foot of gas at any temperature to the same final pressure, provided the initial pressures were the same, and it naturally followed that it took more power to compress the same weight at higher temperatures, because there would be a larger volume and the piston would have to make more strokes.

Altitude acts like an increase of temperature in lessening the density of a gas, but it introduces another element, viz., change of initial pressure, so that as we reach higher altitudes the pressure ratio is constantly increasing, which means, of course, that the temperatures of compression are increasing and more work per unit of gas weight is being done, but the weight is constantly decreasing as we ascend, and the combination of these results is that while it takes less work to discharge any given cylinder full of gas at an altitude, the increased number of strokes necessary to compress a weight equivalent to a given sea level volume is considerably greater.

Table 17, shows a comparison between compressing gas at sea level and at 10,000 feet altitude. The columns 3 to 6, inclusive, comprise the components of the general formula for compressing gas, and it is interesting to note the variable quantities. It will be seen

that while one cubic foot of the altitude gas requires less power, the increased volume necessary to produce a common result makes it require 25 per cent. more power.

It will also be noted that the final temperature is quite high in comparison to sea level compression, which speaks loudly for two stage compression.

FLOW OF GAS IN PIPES.

After reading the report of the committee on "The Flow of Gas in Pipes," for the Ohio Gas Light Association, as published in the *American Gas Light Journal*, April 24, 1905, the general impression would be that the formulæ were not sufficiently reliable to be of great service, because there was a variation in the results of a given problem of from 1 to 200 per cent. It would seem, however, that six formulæ out of the nine do not vary 15 per cent., and the three most frequently used do not vary 2½ per cent.

Table 17. July, 1905.

Altitude.	$\frac{P}{P^\circ}$	$\frac{Y}{Y-1}$	P°	V°	$\frac{T}{T^\circ}-1$	Foot-pounds to compress one cubic foot.....	Equivalent to produce same compressed gas at altitude	Initial pressure	Gauge press....
Sea level	6.44	4	14.7	1×144	.593	5020	14.7	5020	80
10,000 ft.	9.47	4	10.	1×144	.753	6375	10.	4337	80

$T = 390^\circ$ Fah. at sea level.
$T = 450^\circ$ Fah. at 10,000 feet altitude.

If we should accept the largest of these three, called the Pittsburg formula, we would probably not be far wrong, and particularly as the results do not differ greatly from those obtained by using Cox' computer, and I am informed by those who have used the computer that it is perfectly safe.

Again, the variation in the areas of those pipe sizes most likely to be used are much more considerable than the variations of any of the six formulæ above referred to. Thus, taking the commercial sizes of pipe from 1" to 6", the average variation between the areas of each size is 35 per cent.

If we therefore make a practice of using the pipe that is the nearest size larger than our calculations, we shall have an ample safety factor.

For air we have been using a formula developed by Mr. J. E. Johnson, Jr., and published in the *American Machinist* July 27, 1899. (Table 17, No. 2)

$$P'^2 - P''^2 = \frac{.0006\, Q^2 L}{d^5}$$

P' = absolute initial pressure
P'' = absolute final pressure.
Q = free air equivalent in cubic feet per minute.
L = length of pipe in feet.
d = diameter on pipe in inches.

Practical results from this formula show that it is a little too liberal, and that $P'^2 - P''^2 = \frac{.00005\, Q^2 L}{d^5}$ would be nearer the results.

The Pittsburg gas formula reduces to the same value when the proper substitutes are made for the relative specific gravities of gas and air.

Inasmuch as the specific gravity of gas is always referred to air as 1, it seems right that our gas formula should refer to air and a coefficiency used for each gas.

The velocity of different gases through a pipe vary inversely as the square root of their densities, or what amounts to the same thing, their specific gravities or weights compared to air, then the velocities will vary as

$$\sqrt{\frac{G}{I}} \text{ or } \sqrt{G}$$

Where G is the specific gravity of the gas.

Prefixing this to our original equation, we have in general, for any gas,

$$P'^2 - P''^2 = .0005\sqrt{G} \times \frac{Q^2 L}{d^5}$$

Or

$$Q = \sqrt{\frac{44.66}{G}} \sqrt{\frac{P'^2 - P''^2 \times d^5}{L}}$$

TABLE 18 FORMULAE & EXAMPLES JULY 1905

(1) Q=1000 P_1=30 LBS GAUGE d=4 L=26000 REQUIRED P_2

P_1^2=1096.2 (TABLE 14) $P_1^2 - P_2^2$ = 35.04 FOR 100 FT (TABLE 13)

260 X 35.04 = 9110 $P_1^2 - P_2^2$ = 9110 $P_2^2 = P_1^2 - (P_1^2 - P_2^2)$

= 10962 - 9110 = 1852. P_2^2 = 1852 P_2 = 28 LBS (TABLE 14)

(2) d=3" L=11000 REQUIRED Q FOR P_1=40 P_2=2

P_1^2=2932 (TABLE 14) P_2^2=279 (TABLE 14) $P_1^2 - P_2^2$=

2713 FOR 11000 FT OR 24.6 FOR 100 FT TABLE 13 GIVES

420 CUBIC FEET FOR $P_1^2 - P_2^2$ = 24.6

(3) L=11000 d=4" Q=1000 P_2=10 REQUIRED P_1

$P_1^2 - P_2^2$ = 35.04 FOR 100 FT (TABLE 13) 35.04 X 110 = $P_1^2 - P_2^2$ FOR

11000 FT = 3854 P_2^2 = 610 (TABLE 14) $P_1^2 = P_2^2 + (P_1^2 - P_2^2)$

= 3854 + 610 = 4464 $P_1 = \sqrt{4464}$ = 52 LBS.

(4) Q=200 L=53000 P_1=20 P_2=6 REQUIRED d

P_1^2=1204 (TABLE 14) P_2^2=428 (TABLE 14)

$P_1^2 - P_2^2$ = 776 FOR 53000 FEET OR 1464 FOR 100 FEET

TABLE 18 GIVES FOR 1464 Q=200 = 4" PIPE

E.A.R.18.

Inasmuch as certainly for some considerable time crude oil gas will be most extensively used by members of this Association, let us substitute in the above formula the value of the largest probably specific gravity, viz., .40, and we have $\sqrt{.49} = .7$ and

$$P'^2 - P''^2 = .00035 \frac{Q^2 L}{d^5} \qquad (A)$$

Or

$$Q = 63.8 \sqrt{\frac{P'^2 - P''^2 \times d^5}{L}}$$

Q is in cubic feet per minute rather than per hour, because all compressors are so rated.

Table 12 gives values of $P'^2 - P''^2$ for 100 feet for various sized pipes and quantities will be found convenient for figuring gas flows here in California. The values are calculated from equation (A).

The four examples following will be found on Table 18, Nos. 1-2-3-4.

TABLE 13 GAUGE PRESSURES, PRESSURE RATIOS, FINAL TEMPERATURES, VOLUME RATIOS, MEAN EFFECTIVE PRESSURE AND BRAKE HORSE POWERS FOR ILLUMINATING GAS AT SEA LEVEL AND 60° FAH. JULY 1905
÷ SINGLE STAGE. ÷

GAUGE PRESSURE	$\frac{p}{p_o}$	$\frac{T}{T_o} - 1$	FINAL TEMPERATURE T.	ADIABATIC M.E.P.	PRACTICAL M.E.P. AT COMMERCIAL PISTON SPEEDS	BRAKE H.P. TO COMPRESS 100 CU. FT. AT SEA LEVEL & 60° FAH	$\frac{V}{V_o}$
3·00	1·2	·0466	84°	2·74	3·014	1·514	·8063
5·90	1·4	·0870	106°	5·16	5·676	2·85	·7763
8·3	1·6	·1247	125°	7·33	8·063	4·05	·7030
11·8	1·8	·1583	142°	9·30	10·23	5·14	·6436
14·7	2·	·1832	158°	11·17	12·22	6·15	·5948
17·7	2·2	·2179	173°	12·81	14·09	7·08	·5538
20·8	2·4	·2447	187°	14·38	15·82	7·95	·5186
23·6	2·6	·2698	200°	15·86	17·45	8·76	·4885
26·5	2·8	·2966	214°	17·46	19·31	9·63	·4621
29·4	3·	·3161	224°	18·58	20·44	10·27	·4385
32·4	3·2	·3375	238°	19·84	21·82	10·96	·4181
35·3	3·4	·3579	246°	21·04	23·15	11·63	·3995
38·3	3·6	·3774	256°	22·20	24·42	12·26	·3827
41·2	3·8	·3962	266°	23·29	25·62	12·87	·3675
44·1	4·	·4142	275°	24·35	26·79	13·46	·3536
47·1	4·2	·4315	284°	25·37	27·91	14·00	·3410
50·	4·4	·4483	293°	26·25	28·87	14·56	·3293
53·	4·6	·4645	301°	27·31	30·04	15·10	·3183
55·9	4·8	·4802	310	28·22	31·04	15·60	·3086
58·8	5·	·4954	317	29·12	32·03	16·10	·2992
73·5	6·	·5651	354	33·22	36·54	18·36	·2609
88·2	7·	·6266	386	36·80	40·40	20·36	·3225
102·9	8·	·6818	424	40·04	44·04	22·15	·2103
117·6	9·	·7321	441	43·14	47·45	23·80	·1926
132·3	10·	·7783	446	45·85	50·43	25·28	·1779

PRACTICAL M.E.P. = ADIABATIC M.E.P. + 10%
BRAKE HORSE POWER PER 100 CU FT = + 26·5 %
FORMULA HP = $32.5\left(\frac{T}{T_o} - 1\right)$ FOR STANDARD GAS AT SEA LEVEL AND 60° FAH. E.A.RIX.

Example I—

1000 cubic feet per minute of gas at 90 pounds gauge pressure is discharging into a 4" pipe 26,000 feet long. Required the terminal pressure.

$P'^2 = 10962$. (Table 13)

$P'^2 - P''^2 = 35.04$ for 100 feet. (Table 13)

Multiplying by 260 for 26,000 feet

$P'^2 - P''^2 = 9110$.

$P''^2 = P'^2 - (P'^2 - P''^2) = 10962 - 9110 = 1852$.

$P''^2 = 1852$. $P'' = 28$ pounds.

Example II—

A pipe line 3" diameter and 11,000 feet long. Required to find the quantity of gas that will be delivered at a terminal pressure of 1 pound, the initial pressure being 40 pounds.

$P'^2 = 2992$ (Table 13)

$P''^2 = 279$ (Table 13)

$P'^2 - P''^2 = 2713$ for 11,000 feet of pipe or 24.6 for 100 feet.

Referring to Table 13, we find value of 23.70 for 420 cubic feet per minute

Example III—

A pipe line is 11,000 feet long and 4" diameter. The equivalent of 1000 cubic feet (Table 13) is wanted at the end of the line at 10 pounds pressure. What must be the initial pressure?

$P'^2 - P''^2 = 35.04$ for 100 feet (Table 12). Multiplying by 110 we have

$P'^2 - P''^2 = 3854$ for 11,000 feet.

$P''^2 = 610$ (Table 13)

$P'^2 = P''^2 + (P'^2 - P''^2) = 3854 \times 610 = 4464$.

$P' = \sqrt{4464}$.

Referring to Table 14 we find 52 pounds gauge pressure to be the initial pressure.

Example IV—

The equivalent of 200 cubic feet per minute is to be put through a pipe 53,000 feet long. The initial pressure is 20 pounds. The final pressure must be 6 pounds. What will be the size of the pipe?

$P'^2 = 1204$ (Table 13)

$P''^2 = 428$ (Table 13)

$P'^2 - P''^2 = 776$ for 53,000 feet of pipe or 1.464 per 100 feet. Referring to Table 13, we find 4" to be the proper size.

SOME CORROBORATIONS.

Table 15 gives at Figure 1 a card from the gas cylinder of a compressor at Fresno, compressing crude oil gas at a pressure of 27 pounds gauge.

If we draw the line of 27 pounds pressure and take the $M\ E\ P$ with a planimeter, following the curve $A\ B$ and the straight lines $B\ C$—$C\ D$ and $A\ B$, we shall have the $M\ E\ P$ of a perfect card following the actual compression line. This $M\ E\ P$ we find to be 17.4 pounds, using the Y which we found for Fresno gas, the adiabatic $M\ E\ P$ for 27 pounds = 17.58, making a good check on our values.

Figures 2 and 3 are from a compressor pumping natural gas at Anderson, Indiana, each having an intake pressure of 11 pounds—drawing lines of 50 pounds pres-

sure at Figure 2 and 60 pounds at Figure 3, and taking the *M E P* in the same way that we did in Figure 1, we find that the *M E P* for Figure 2 is 26 pounds, and for Figure 3, 30 pounds.

Using the value of *Y* which we developed for natural gas and calculating the adiabatic *M E P*, we find they are 26.30 and 30.85 pounds, respectively, a very satisfactory check, and from these we may fairly conclude that our theories and formulae are reasonable.

It will be noted that the line of the compressor curve is very near the adiabatic, even though the compressors were making but 60 to 70 revolutions per minute. An air card would show at least double the separating space.

This would appear to show that the jackets were doing but very little good, and possibly because illuminating gas may be a much poorer conductor of heat than air.

The line of compression comes so near the adiabatic that we may well call the compression adiabatic for safety in our calculations—but while the *M E P* adiabatic for any pressure represents the greatest possible power required to compress a gas, a still greater power must be applied—for example look at the Fresno card, Figure 1, Table 14—the area above the 27 pounds line represents work done in overcoming the inertia of the outlet valves in pushing the gas into the main, and this area will be greater or less depending upon the valve area and the size of the discharge openings and the piston speed. It will also be noted that there is an area representing suction work below the line *A D*, notwithstanding that the gas has a 4" water pressure at holder. This probably indicates that the pipes from the holder to the compressor are too small.

Now, if we run a planimeter over the actual area of the card, we find that the real *M E P* is 19.4, or about 10 per cent. greater than the adiabatic, and this agrees quite well with ordinary air practice, where a safe rule for single stage work is to take the *M E P* at 10 per cent. above the adiabatic and the two stage *M E P* the same as the adiabatic. Slow speed, well constructed compressors will do somewhat better, but it is well to calculate on the average type.

Now, for brake power to be delivered to a gas compressor, we have to allow a mechanical efficiency of the compressor at not to exceed 85 per cent., so that this 15 per cent. loss combined with the 10 per cent. loss in the cylinder points to the fact that we should add 26½ per cent. to the adiabatic *H P* for the brake power required.

The steam engine cards on the Fresno compressor show an *M E P* reduced to the size of the air cylinder of 20.75 pounds, or 20 per cent. higher than the adiabatic air *M E P*, but this compressor had a Neyer cut-off, which helped its economy considerably.

Referring to Table 9, column 17, gives the formula for computing the power to compress one cubic foot of the gas at sea level and 60° Fah. If the calculation be made it will be noted that it takes practically the same power to compress one cubic foot of any of these gases, consequently Table 19 may be used generally.

In conclusion your attention is called to Table 19, which contains in convenient form the results which we have obtained, and which it is hoped you will find very helpful in considering thermodynamic questions regarding the standard illuminating gas made from crude oil.

EXPERIENCE DEPARTMENT.*

BY R. P. VALENTINE, EDITOR.

The report of the Experience Department for the present year is not an extensive one, but the editor trusts that it will prove of interest to the members of the Associaion. Verbosity is not always necessary to success. There is no reason why this department should not remain a distinct feature in our program, and we hope that it will always command the patronage of those that take an active interest in our proceedings. It is the quality of the contributions that counts, but, nevertheless, there should be no hesitancy on the part of the members in the matter of contributing.

Our prime purpose is to present valuable facts, edification being a matter of less than secondary consideration. This being the case, we respectfully submit the following concise report:

A FEAT IN TRANSPORTATION.

From San Francisco comes the novel description of moving an immense holder by water, on a barge. It is needless to say that if this method had been inexpedient, the indomitable gas man would have got there just the same. We were in need of oil storage at our Potrero station, and inasmuch as we had two holders, which were too small for our use at the Equitable Works, we decided to move them and convert the lower tanks into oil storage. We found that there was ample thickness to increase the size of the tanks, and, therefore, are figuring on extending same when they are in new position, some twelve feet. This will make each tank 25,000 barrels capacity.

After a great deal of difficulty with a great many contractors we finally persuaded the present contractors that it was feasible to move tanks over on barges, and Messrs. Blume and Cramm took the contract to move the tanks.

After taking out the two lifts, the top, and taking down the frame, poles were erected on the inside over the points where the stringers, which were to be used in lifting the tank, were to be placed. From these poles wires were run to the outside edge of the tank and the tank trussed as it were, so that there would be no bending of the bottom, and so that the side would not get out of place. This transferred most of the weight directly on to the rollers. The tanks were then wedged up as high as convenient and then jacked to about five feet above ground. Under these were placed the ordinary timbers used by house-movers and rollers. The tanks were then skidded out to the edge of the wharf, which

*A paper read before the Thirteenth Annual Meeting of the Pacific Coast Gas Association, July 18, 19, 20, 1905.

had been braced to carry same, and a barge pulled alongside at high tide, and the tank was moved out on to the barge; meantime the tide went down and left one corner of the barge supporting the outer corner of the tank—the other side of the tank remaining on the wharf—the tank, however, being shifted far enough ahead to be in a permanent position on the barge. When the tide came up the barge lifted the tank clear of the wharf and was towed out to stream.

The method of taking the tank off at Potrero wharf was similar to loading same—the barge being hauled at high tide to a concrete and stone bulk-head, and was hauled off the barge on the second tide after it had arrived there. The matter of moving tanks to the foundation was a simple proposition, and while at this writing the same are not there, it is only a matter of a few days before they will be in permanent position and ready to extend the twelve feet. The total weight of the tank was, approximately 169,000 pounds. The tanks were seventy-two feet six inches in diameter and twenty-five feet high, while the barge was forty feet wide, leaving as you will see quite a projection which was cared for by the trusses in the tank.

Appended to this experience I find the following newspaper clipping, which is an example of newspaper exaggeration:

"The unusual sight of seeing a huge gas holder seventy-five feet in diameter and thirty-six feet high, being towed up the bay on a barge, caused much comment along the water front late yesterday afternoon. The great tank looked like a big, black balloon as it slowly moved along, towed by the tug Milton. It loomed up over everything in the harbor as it passed along to its destination at the new gas works at the Potrero. This huge tank, which weighs 150 tons, was originally used at the Old Equitable Gas Works plant at the foot of Hyde street. When this property passed into the hands of the San Francisco Gas Company that corporation decided to dismantle the works. The tank and one similar to it are to be used as oil tanks for crude oil in the new plant. Blume & Cram, who have the contract for moving the tanks, expect to send the second one to its new home Friday. When this is done the old gas works will be completely dismantled and the Equitable plant will soon be a thing of the past."

WHAT WAS THE TROUBLE?

The following interesting experience is an example of the many difficulties, sometimes almost inexplicable, that are sure to arise, now and then, wherever gas is manufactured:

"At our works we have two water pumps, one operated by electric power, and the other by steam. The steam pump being used when the electric power is not available. When the steam pump was installed the suction was increased from two to two and one-half." Not long after the change I was called to the works to find that the electric pump would not give forth any water and when started would hammer and throw the belt. The steam pump was started and pretty nearly tore itself from the foundations. After stopping and starting several times, with the same results, no water and much noise, we concluded that our well had caved or filled with sand. Temporary pipes were run to a neighboring mill, and a supply of water obtained for the works. We then removed the suction pipe, examined the foot valve and sounded the well, without finding our trouble. The suction was replaced and the pumps again started, and everything worked properly. Once afterward, when running the steam pump, the trouble occurred again, but in a milder form, and after stopping the pump for a little while it worked all right when again started. This occurred several months ago and not since. The only solution we could figure out was, that there must be a piece of sack in the well which found its way to the foot valve, and then settled back into the well, which is sixty-five feet deep, and the suction thirty-four feet long. Wonder what really was the trouble?

EXPERIENCE WITH LAWN SPRINKLER SUPPLY TO SCRUBBERS.

We had been greatly troubled by a lack of efficiency in one of our scrubbers, and naturally turned to the water supply to look for the trouble. The water had been injected through iron disc sprinklers, and upon investigation these were found to be choked and almost filled with shavings, tar and sand. Shortly afterward we experienced similar difficulty with our new scrubber. In this the water had been supplied through cone-shaped spouts, which were closed at the end, and cut with slots. In the first case we cleaned the lawn sprinklers by forcing steam through them. In the second case we did away with the spouts entirely and ran open, vertical pipes to within sixteen inches of the grating, allowing the water under ordinary pressure to strike upon pieces of sheet iron, three inches square, thus splashing it about. In both instances we connected steam pipes to the water pipes in such a manner as to enable us to shut off the water and turn on the steam whenever advisable. This scheme obviated all possibility of further stoppage.

"USE GAS OR GET OFF THE STREET."

Mottoes, epigrams and catchy, suggestive words or phrases are the proper "stunt" in advertising nowadays. Many fortunes have been lost through a failure to advertise wisely; and many men, often undeserving, have become right, through the effect of some little word or phrase that they have flaunted before the public. In advertising, the æsthetic or intellectual qualities of style are not to be considered. For instance, here is a company that has adopted the slogan "Use gas, or get off the street." It can hardly be claimed that the people accepted this imperative statement literally; but the company in question made the remarkable assertion that, though the working out of this bit of poesy, the number of stoves, ranges, hot plates and heaters supplied by them, has

grown to 105% of the number of meters. There is something for all of you to take under consideration. Scratch your heads, a little thinking, a little originality, and a few words may mean unhoped for success.

HOW THE TROUBLE WAS FOUND.

We have eight purifying pans connected in series of four, with a center valve for each set. One of the pans in the set nearest the exhauster commenced blowing, seemingly without cause. On cutting this pan out, the one next to it blew its seal. As our center valve is so constructed that we could cut out one pan at a time, and it being necessary to keep both sets in operation, something had to be done at once, so we sealed the pan that was blowing with dirt packed very hard. We then started up our exhauster, when the next pan to the one we had just treated so harshly started to blow. We gave its seal a dose of dirt, and again tried to start up our exhauster, when our third and last pan gave us an exhibition of a spray fountain (so familiar to the gas man), and we resorted to the same drastic treatment. We now found ourselves in a condition to force the gas through the purifying pans, but only under a tremendous pressure. In fact, we blew the water out of an eighteen-inch pressure gauge glass. For the moment we were stumped. That stoppage had to be found, so we tapped the pipe between this set of pans and our distributing holder. This gave us holder pressure, showing conclusively that our trouble could not be between the pans and the holder, and that we must look elsewhere. Our next move was to tap the pipe near the center valve of our second series of pans, between it and the exhauster, when, to our surprise, we found almost no pressure. This led us to believe that there was a stoppage in the pipe, feeding the second series of pans, and caused practically all the gas to flow through the first series of pans, and in doing so had overtaxed the capacity of the outlet pipes and center valve of this set to such an extent that the pressure was raised to a point higher than the water seal could stand. We now proceeded to tap an one and one-quarter inch hold in the under side of an elbow near the center valve of the second series of pans and the flow of tar that followed was certainly good to see, as we realized that we had ridden ourselves of a very "objectionable lodger." Our troubles in this respect were over, but we did not rest until we had tapped several holes in the under side of our purifying pan feeders, connected steam pipes, and arranged for handling any tar that might come our way.

AN EXPERIENCE WITH RUSTY PIPE.

The plain and steel tubing for use in high-pressure lines came from the factory last winter on flat cars, and in consequence was badly rusted before it could be gotten under cover. Cleaning machines not being immediately available, a part was cleaned by hand and efficient tools proved a serious problem. Course and fine files were not much of a success because they would not clean out pitted spots and irregularities in the surface of the pipe without removing valuable metal. Emery cloth and sand paper did not last long enough to make a showing. Steel wire casting brushes proved quite efficient, coarse brushes being used to loosen the larger pieces of scale and rust and fine brushes to work into the pitts and clean the dust off. Soft red brick, such as would be used only for filling and furnace slag were found excellent, the fine particles working into the pitted spots and irregularities as they broke off. The dust left can best be removed by a fine wire brush, leaving the surface of the pipe clean and bright ready for receiving the paint.

CLEVELAND MIGHT HAVE WORN THIS MANTLE.

Mr. I. C. Carter, superintendent of the gas works at Pomona, has a piece of gas apparatus in the parlor of his home which has been in use for nine years. Considering the destructive qualities of the article itself, this is probably the most remarkable fact in gas history. It is nothing more nor less than a Welsbach mantle which was probably one of the first mantles shipped to this country, and was given to Mr. Carter by a close friend of one of the parties originally interested in the Welsbach patents, to whom it had been sent. The gentleman handed it to Mr. Carter, stating that it had been sent him and he (Mr. Carter) could do what he pleased with it, but that to be very careful of it as it was liable to explode and set fire to the premises, and that it was given him (Mr. Carter) with the understanding that the giver would not be responsible for any damages which might result from it. This was nine years ago, and the mantle is still giving forth light. It would seem that the mantles were better made nine years ago.

AN EXPERIENCE IN OIL GAS MAKING.

It was the day before Christmas. We reached the limit of our capacity at the plant, and knowing the demand during Christmas week for our product would be so great that unless something was done in order to make gas and provide for the emergency that our holders would be touching bottom, and you know what that means in a city where competition is so keen as in this. I have seen you fellows make oil gas in California, and have often thought what a cinch was yours—that all you had to do was to turn on your oil tap, make your gas, sell it, and then sit in an arm chair with your feet on the desk and wait for your dividends to come along; but my experience in making oil gas is not so rosy. In order to supply the demand, anticipating the emergency, early in December I ordered twenty-five barrels of oil from the Union Oil Co. of San Francisco. The emergency arose on December 23d, and we commenced operations. We drilled a hole in the centers of the retort lids of a bench of 6s; having filled a tank holding about 150 gallons of oil, making a nozzle out of a piece of one-half-inch pipe. After the six charges of coal had been cooked we sprayed the oil on the white-hot bed of coke under a pressure of about sixty pounds. The process of injecting the oil lasted about forty-five seconds. When all was ready, the foreman, with his hand on the cock supplying the oil, and myself in the exhauster room watching the exhauster anticipat-

ing that the velocity of the new gas would be such as to make the revolution of the exhauster bust something up, I gave the word to turn on the oil. The oil was injected as I before stated, for about forty-five seconds. A plug was put in the aperture and the process repeated in the next retort, and so on until we had treated all six alike. I was aware of the fact that you have a relief holder in which you make your first gas before condensing and purifying, but we took our chances on this. With the exception of a slightly increased rate of speed, the exhauster did not show that it was taking up the gas that was being made, so after the round of the six retorts we started again and repeated the operation, but we were not making any gas to speak of, but the oil was certainly being used. Not being able to explain satisfactorily the cause of our non-success, we thought probably the time necessary for injecting the oil was not long enough, so we increased it to one and one-half minutes, but with apparently no better result. In a state of great disappointment, bordering on despair, with only two and one-half sheets of gas in the holder, I walked around the yard gazing heavenward—probably for inspiration as to what to do—and saw, not our blue northern sky, but an atmosphere of smoke that made me think I was walking the streets of Pittsburg. Looking at the chimney stack I saw a vast column of smoke emerging, enough to suffocate the town. I then made gas like smoke it should go through the exhauster knew that something was wrong in the retorts, as if oil anyhow, and not through the chimney, and we were burning oil up at the rate of $2.65 per barrel. The foreman informed me that he had selected the oldest bench we had. I had the lids taken off, and looking in the retorts found four of them with great big holes which you could put your head into. I felt like putting someone's head into them. Instead of seeing the holder rise triumphant from the ground, what gas was being made was in the form of smoke. It was all going up the stack and the elements were being treated to a taste of oil gas in its natural state. We repeated the trial on a good bench and once again commenced to inject the oil for 45 seconds. You should have seen the exhauster go to work. It was a pleasure and a treat to me, more than any I have experienced during my long years in the profession, with a feeling from almost complete despair to that of triumph in the knowledge that we had emerged from as deep a hole as it was possible for a gas man to be in. The consequence was that not only did we overcome the difficulty we were in, but our consumers stated that Christmas Eve they had better gas than they had ever had. Thank the Lord, we will not have to relate a similar experience through shortage of bench capacity the coming year. It was expensive gas-making, but we supplied our consumers with gas all the same.

The editor wishes earnestly to thank those that have contributed to this report, and hopes that the success of this deparment will be more pronounced in future conventions.

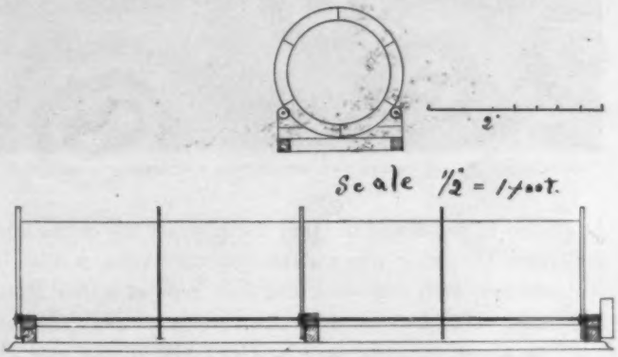
WRINKLE DEPARTMENT.

Before I read the Wrinkles that have been sent me by the members, I wish to thank those who have so kindly contributed to this department.

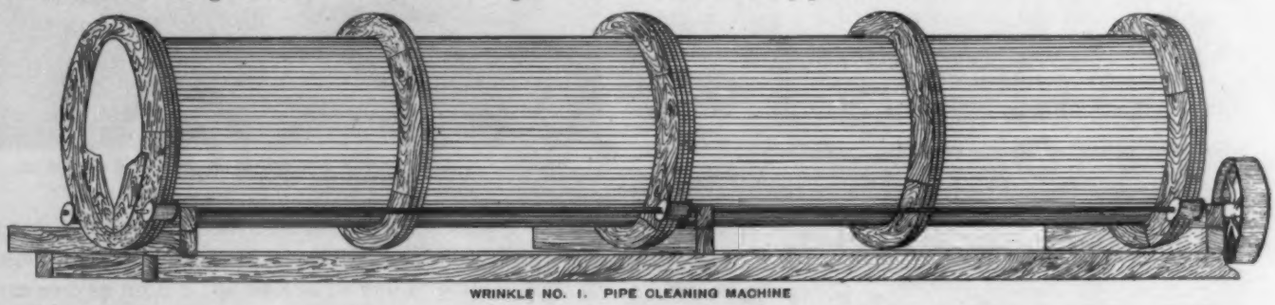
WRINKLE NO. I.—PIPE CLEANING MACHINE.

This pipe cleaning machine was designed to prepare rusty or oily pipe for painting.

This is a well known fact that painting rusty or oily pipe is useless, as the paint will not stick to the pipe but will come off in pieces the size of the rust or oil. This machine does not only remove rust and oil from the pipe but it also removes all scale that might be on the out or inside of the pipe.



WRINKLE NO. I. DETAILS OF PIPE CLEANING MACHINE



WRINKLE NO. I. PIPE CLEANING MACHINE

This machine is a wooden drum four feet in diameter by twenty-two feet long, and will work best at about ten revolutions per minute. It will clean twenty-four pieces of two-inch tubing in from thirty to forty minutes.

When the pipe is placed in the drum a sufficient amount of sharp sand should be put into the drum that the pipe will be covereted or nearly so. After the first charge add what sand is necessary.

To tell how many pieces of pipe of different sizes should

WRINKLE NO. 2. THE PARKER PIPE WRENCH FOR SCREWING UP PIPE LINES

be placed in the drum see that the pipe on top drops and rolls over the other pipes about one each turn or so. If it drops too often remove a length of pipe at a time from the drum. If it does not drop at all add more pipe. When used as above the pipe will be clean and bright and all scales will be found removed in and outside. The pipe is then ready for painting.

The writer has used the machine and cleaned about eight miles of two-inch steel tubing which was in bad condition. It kept four men busy painting. This pipe was painted with two coats of red lead and piled up in the yard, subject to the weather. This was done about the first of this year and each length of pipe is in perfect condition now. This pipe has been carefully inspected from time to time. The cost of operating this machine is merely the cost of power and of handling the pipe.—H. WEBER.

WRINKLE NO. 3. THE PARKER PIPE WRENCH SCREWING UP TEN LENGTHS OF PIPE SIMULTANEOUSLY

WRINKLE NO. 2.—EXHAUST HEAD ON GAS ENGINE.

At one of the plants of the California Gas & Electric Corporation, a 30 horsepower gas engine was installed to run a compressor. The overflow from the water jacket on the cylinder was connected to the three and one-half exhaust pipe to cool the gases, as the pipe went through the roof. It was found that the exhaust carried the water a considerable distance into the air, scattering it all over the roof. As a high tension switch board was located in the building it was considered advisable to prevent the water scattering if possible, so put on a four Sturtevant exhaust head, which not only took care of the water in good shape but acted as a muffler as well.—C. COPE.

WRINKLE NO. 3.—PIPE WINCH FOR SCREWING UP PIPE LINES.

In operating the machine the men are first sent ahead to screw ten lengths of pipe together, hand tight, then the machine is attached to the line with the aid of a knuckle joint, (see photo No. 4) the men take positions as shown in the photo No. 2, wishing to increase their power they change to positions as shown in photo No. 3.

The advantages gained with this machine are: It does

WRINKLE NO. 3. THE PARKER PIPE WRENCH, SHOWING THE METHOD OF OPERATING THE RATCHET HANDLES

rapid work; it does not damage the pipe as tongs do; it screws all of the threads up out of sight in the couplings; there is nothing to unload or load up; it is on its own carriage; three men did screw up twelve miles of pipe in twenty-five days, between Oxnard, Cal. and Ventura, Cal.

The apparatus was made out of two hay rake wheels and a piece of two-inch shafting, two gear wheels three to one. The balance is junk from a machine shop. The entire pipe line stood 100 pounds air test.—WILLIAM M. PARKER.

WRINKLE NO. 4.—STEAM BURGE ON OIL LINE ON GENERATOR.

In some oil gas plants it is found that a good deal of carbon forms in the oil burners and also on the tips. On tracing the trouble up it was found that the oil left in the

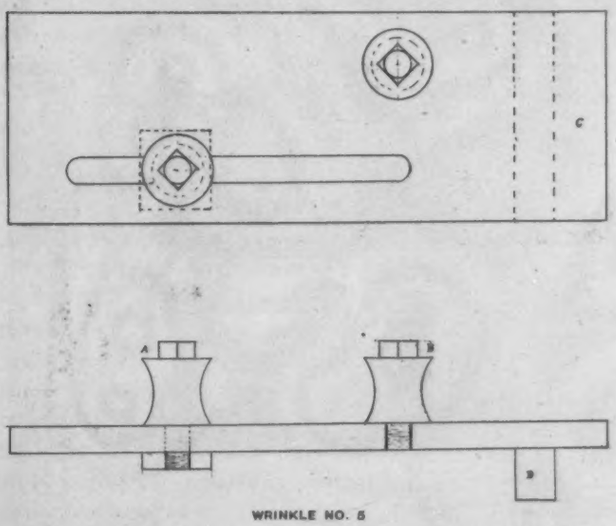
WRINKLE NO. 3. THE PARKER PIPE WRENCH, BEING THE REVERSE OF THE PRECEEDING VIEW

pipe between the controlling valve and the burner on shutting down the machine, would run very slowly to the burner and there carbonize. I connected a steam pipe to the oil line, close up to the controlling valve, and on shutting down the machine, blew out all the oil left in the pipe and found the troubles greatly diminished..—C. COPE.

WRINKLE NO. 5.—ADJUSTABLE PIPE-BENDING DEVICE.

The pipe-bending apparatus shown in the illustration, which can be adjusted to vary the radius of the curve to be bent, is so simple that any workman could make one like it, says the correspondent of the *Engineer's Review.*

To the plate (C) is fastened a stud, (B), while the stud (A) moves in a slot in the plate. The pipe is bent between these two studs by prying in the direction in which the pipe is to be bent. The movable stud regulates the radius



WRINKLE NO. 5

of the curves. The rib (D), is for holding the plate in the vise while bending pipe.—*From Popular Mechanics.*

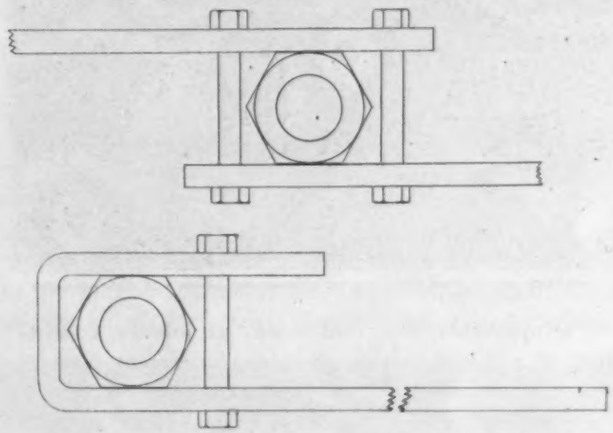
WRINKLE NO. 6.—TO INTRODUCE FRESH AIR INTO SCRUBBER WHEN WORKING IN SAME.

Make two-inch tap in blast pipe on the blower side of the blast pipe gate, run two-inch pipe to lower door of supply of fresh air is kept passing through the scrubber supply of fres hair is kept passing through the scrubber from the bottom to the top and the workmen will experience little difficulty with the fumes encountered in the scrubber.

When it is found necessary to remove scrubber trays for cleaning, we give the scrubber a good steaming, then turn on the water, allowing the scrubber to thoroughly cool. The fresh air supply is then admitted and the work of removing the trays goes forward rapidly, as the steaming and washing mentioned dries the surface of the tar and makes the trays much easier to handle. The results we obtained were thoroughly satisfactory.

WRINKLE NO. 7.—MAKING LARGE WRENCHES IN EMERGENCY FROM THE FULCRUM.

For turning nuts on large unions where there is no wrench of a size suitable for the work in hand, it is not always necessary to forge a wrench. For a brass union on a two and one-half-inch pipe, take two pieces of

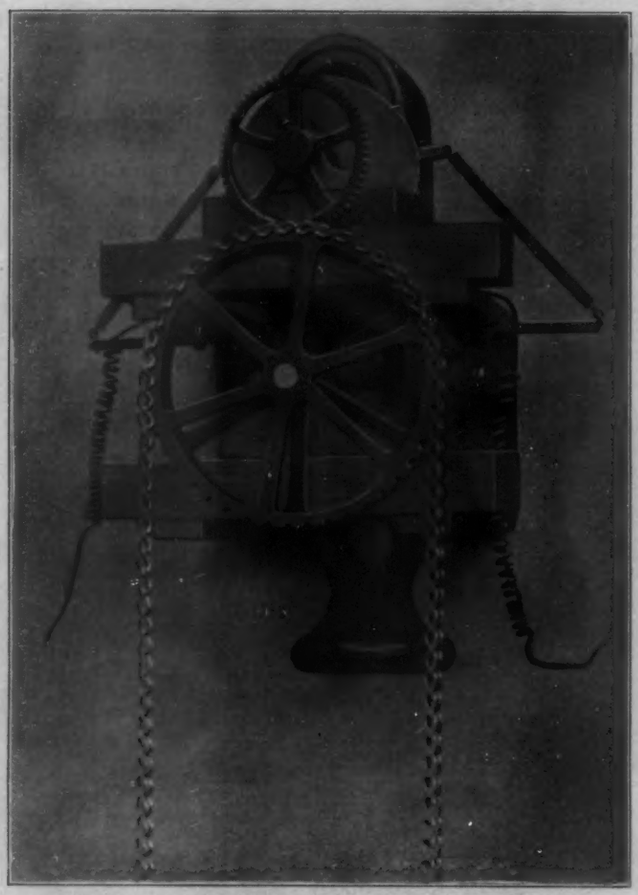


WRINKLE NO. 7. LARGE WRENCHES. FIGURES 1 AND 2

iron about one-half inch by two and one-half inches and eleven inches long, and two one-half-inch bolts. Bore holes for the bolts, and screw up as shown at Fig. 1. The two projecting ends coming on opposite sides will serve as handles for turning. Friction is reduced by applying force on two sides of the pipe. Where there is not room enough to use this wrench, heat a single piece of iron, bend it into the shape of Fig. 2, and join with one bolt. Turn by means of the long handle.

WRINKLE NO. 8.—RECORDING INDICATOR FOR GAS HOLDERS.

Where gas holders, reservoirs, oil tanks, etc., are located at distant points, a device to denote the amounts contained in such storage places is always found useful. An electric call bell is the simplest, but this only serves as an alarm to tell when a holder or reservoir is either full or empty, and is sometimes confusing, even then, to know whether the bell rung was intended for the full or empty point. The indicator here described not only indicates every inch of the holder in the process of filling or emptying, but records it as well on a strip of paper, so at a glance the amount of gas that was contained in the holder at any hour of the day can be ascertained.



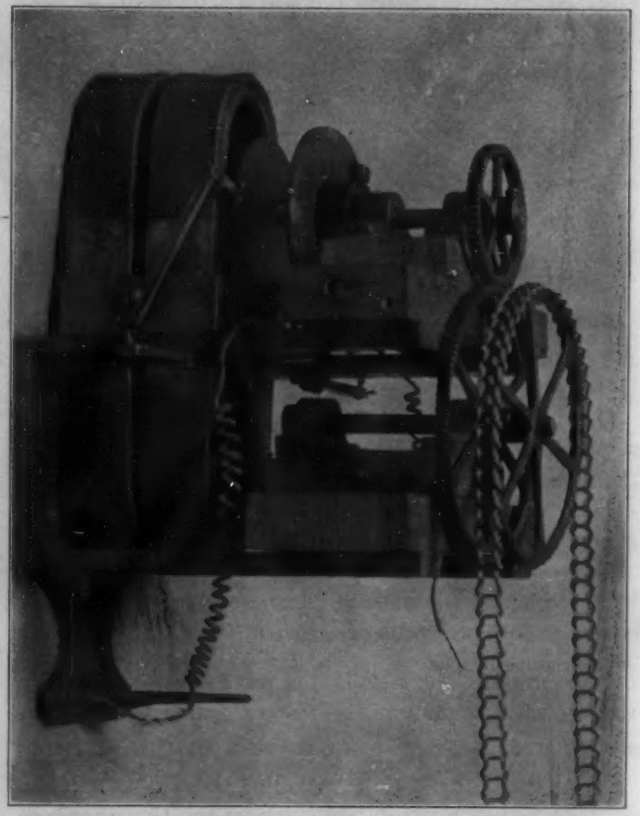
WRINKLE NO. 8. THE STERLING RECORDING INDICATOR FOR GAS HOLDERS

The apparatus, described briefly as follows, consists: first, of a device to send impulses of current from the holder to the receiving point over a single iron wire. This is a small magneto generator, such as used for telephone call bells, but having a commutator so as to give direct current. It is actuated by a sprocket chain, one end attached to the holder and at the other a ten-pound weight. The sprocket wheel carries a revolving disc on which are four projecting pins which in succession engage in a crank on the armature shaft, which shaft is held in a given position by two opposing springs. As the sprocket wheel and disc slowly revolve as the holder is moving, say, in a downward direction, the armature is likewise carried with it for a quarter of a revolution by one of the pins before mentioned and, being suddenly released, is carried back quickly by the spring brought into tension and thus generates a current in a certain direction. Should the holder be filling and going upwards, the same operation would be repeated, but in this case the armature revolving in a reverse direction, necessarily produces an impulse of current opposite to the first one. By suitably proportioned gears, these impulses of current can be made to take place at any desired interval, and, in practice, every two inches travel of the holder has been found ample. We thus have a device to generate a positive current at every two inches travel of the holder upwards, and a negative current at the same interval on the downward journey. It is, then, a simple matter to arrange a recording apparatus at the other end of the line, whereby a pair of polarized electro-magnets are energized in turn by either the positive or negative current from the gas holder. The armatures of these magnets operate a pall and ratchet wheel, one magnet causing the wheel to revolve step by step to the right, and the other to the left. There is thus produced two directions of rotation, and a pen attached to an arm, traveling up and down, records on a strip of paper carried by a clock having a twenty-four-hour revolution, the exact performance of the holder during that space of time, for perpendicular lines on the paper indicate the hours, and horizontal lines the capacity in feet of the holder.

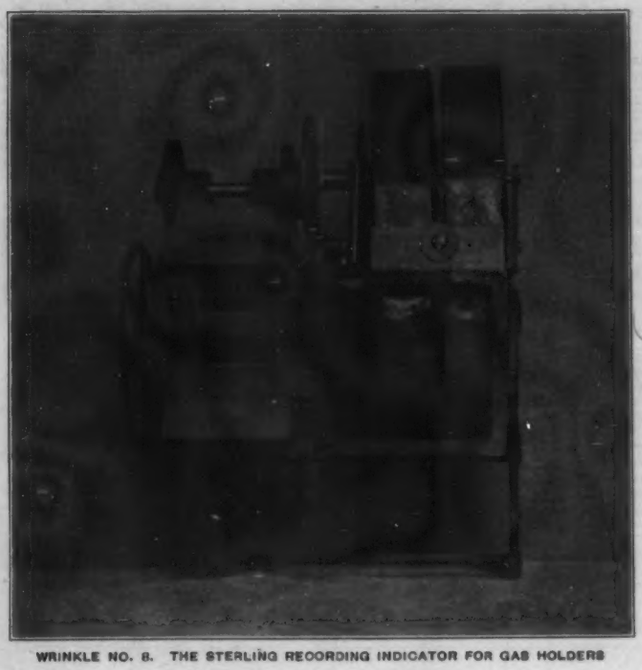
Records of this kind become as interesting as the ampere load readings of a power station, for the different peaks of the day are shown, though in the case of a gas plant they become valleys, instead, and in our case, where the holder is located a mile from the gas works, a device of this kind is of great help to the gas maker, for his gauge-board is reproduced on paper as accurately as though the holder was near at hand.—R. H. STERLING.

WRINKLE NO. 9.—A WAY OF STOPPING SAND HOLES IN COUPLAR CASTINGS.

During the construction of several high pressure pipe lines which consisted of plain end steel tubing joined with couplars of the Dresser and Hammon type, nearly twenty per cent. of the cast-iron sleeves or barrels leaked when tested with compressed air, and replacing defective cast-



WRINKLE NO. 8. THE STERLING RECORDING INDICATOR FOR GAS HOLDERS



WRINKLE NO. 8. THE STERLING RECORDING INDICATOR FOR GAS HOLDERS

ings, and retesting, became an appreciable part of the cost of installation of the pipe lines. Acting on a limit regarding the experience of parties who built a natural gas line in the East, we are now boiling all couplar sleeves in paraffin before putting them in place. Gas will not dissolve paraffin and it will fill the porous places in cast-iron when the casting and wax are at the boiling temperature. For convenience in handling, the castings are boiled in baskets made of wire netting. Two hours is sufficient time to allow for the paraffin to enter all pores in the iron, and the boiling is best done in a small tank containing a small steam coil. Before boiling, the castings should be cleaned inside and out, and it is probably best to heat the larger sizes before putting them into the paraffin. Thus far the expedient has proved an entire success, not one of the first lot treated showing a leak of any kind.—C. E. BRECKENRIDGE.

WRINKLE NO. 10.

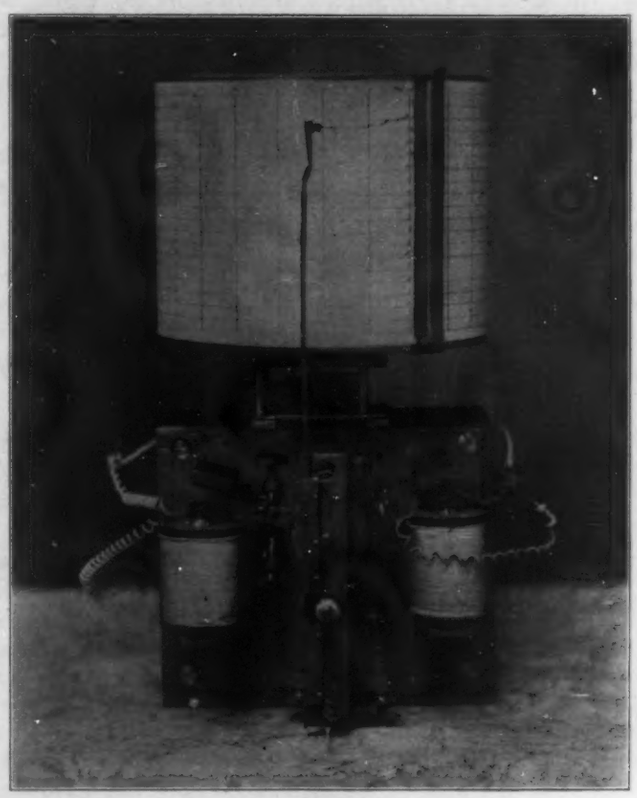
The testing of high pressure gas mains with compressed air is so imperative, and the results have proved so satisfactory, the writer believes that all piping laid in the ground, either cast-iron or wrought-iron, should be tested with pressures consistent with the working pressure of such pipe. To facilitate the testing of mains with pressure up to 100 pounds per square inch, a portable testing rig with air compressor engine water and gasoline tanks were permanently placed upon a steel wagon having a pole attachment to enable it to be drawn by two horses, this portable testing rig is shown in Pictures No. 1 and No. 2.

Picture No. 1 is a side elevation showing a six-horsepower gasoline or distillate engine belted to a 6 in. by 6 in. Laidlaw-Dunn-Gordon compressor with a capacity of thirty feet displacement at 150 revolutions per minute. It also shows a small centrifugal pump belted from the engine. This pump handles all of the water needed for cooling. It first supplies the water to the compressor, then to the gas engine, after which the water is cooled and returned to the tank.

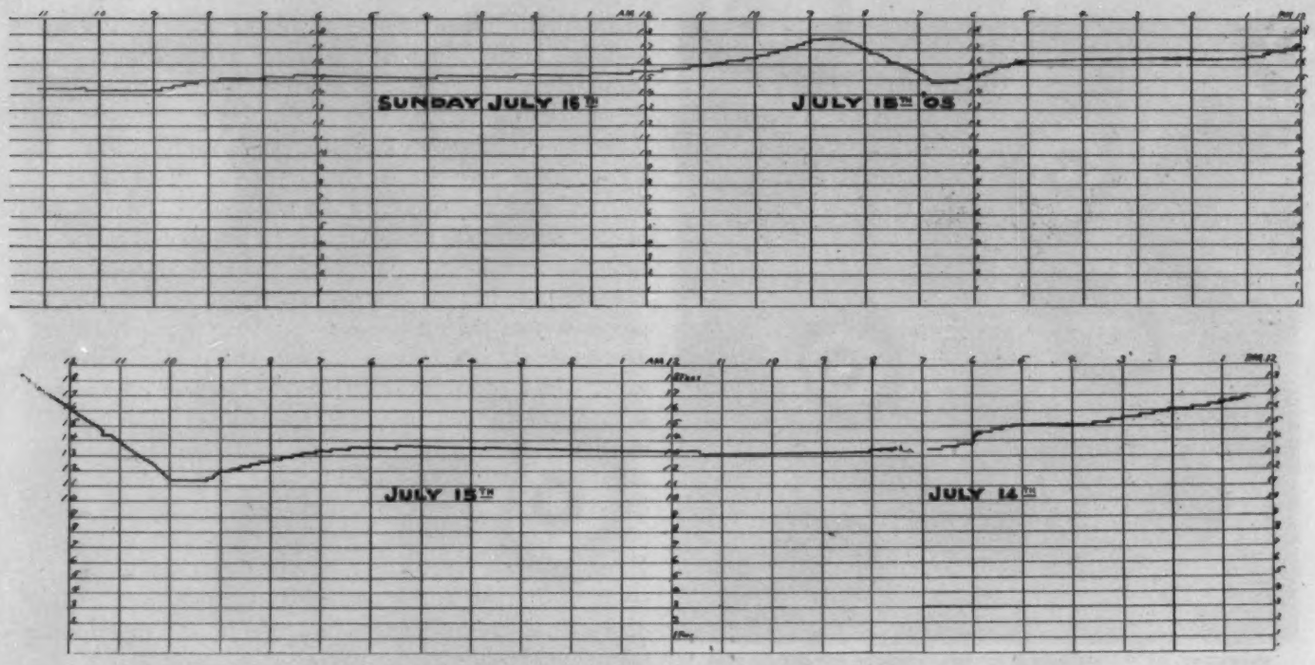
Picture No. 2 shows a perspective elevation of the rig, and it will be seen that in addition to the use of batteries for obtaining the spark for the gas engine, there is an exciter driven from the wheel of the engine. The rig is equipped with fire and water hose, and a suitable tool box. The fire hose may be attached directly to the centrifugal pump, so that the rig becomes its own fire extinguisher. The whole rig is substantially made and is provided with water proof curtains which may be used to enclose all sides of the rig and keep out rain or dust. This testing machine is best used during the early morning or late afternoon. If it is necessary to close in the ditch after a day's work, it is well to test the pipe during the early evening and go over the joints carefully with soapsuds. If the pressure at the gauge does not hold up, or if stretches of main can be left uncovered, this work can be done during the morning hours. In testing gas mains, temperature must be taken into consideration.—E. C. JONES.

WRINKLE NO. 11.

Another and very important use for the portable testing rig is its application to pneumatic tools for cutting pipe and caulking joints. The compressor furnishes enough air at sufficient pressure to operate a pneumatic hammer, which may be purchased at small cost in almost any city or town. To this hammer may be applied diamond points or cape chisels for cutting pipe, and fulling and caulking



WRINKLE NO. 8. THE STERLING RECORDING INDICATOR FOR GAS HOLDERS



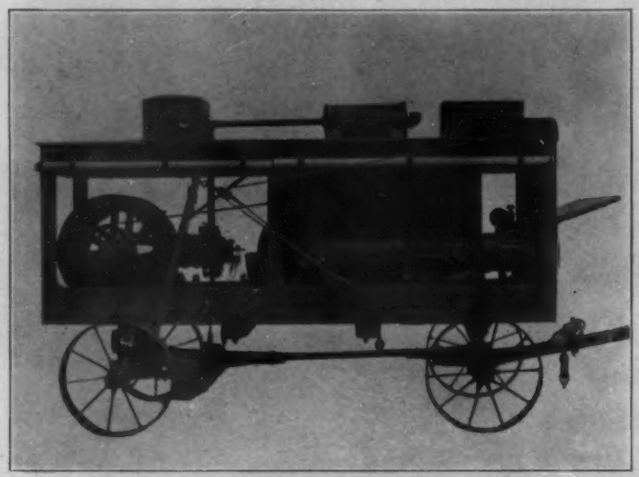
WRINKLE NO. 8. THE STERLING RECORDING INDICATOR FOR GAS HOLDERS

tools for making lead joints may be made for the hammer. The hammers are usually supplied with a hexagon chuck, and it is found best to have the shanks of the tools made round so that the tool is loose in the hands of the workmen. This method of caulking lead joints saves time and money, and insures equal caulking on all parts of the joint. A man with ordinary intelligence can use it, and it relieves the gas company of the use of skilled caulkers, who are hard to obtain, and if not conscientious as well as skillful, will not caulk the under side of the joint.

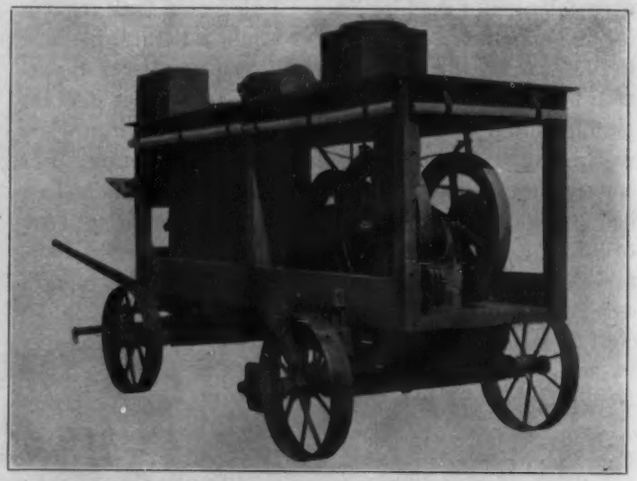
This wrinkle was suggested to me by Mr. A. J. Vanderwhite, of San Francisco.—E. C. JONES.

QUESTION BOX.

QUESTION: What difference does it make in operating a gas plant if the unclean gas is stored in the holder until needed, and then purified out through the boxes to the street mains, instead of first purifying it into the holder and then out to the street mains?



WRINKLE NO. 10. FIGURE 1. TESTING HIGH PRESSURE GAS MAINS



WRINKLE NO. 10. FIGURE 2. TESTING HIGH PRESSURE GAS MAINS

ANSWER: At the time, each day, of greatest consumption, the purifying boxes would not be equal to the task; if it became necessary to cut out all of the boxes, dirty gas would be going into the mains.

ANSWER: Among the disadvantages of such a plan would be: The exhausters, purifiers and station meters would have to be equal to the maximum hourly output.

The gas would be purified at too low a temperature.

Temporary stoppage of the exhausters would result disastrously.

The pressure at the outlet of the works would be very difficult to regulate.

QUESTION: Is it possible by the use of too much cold water in wash box and scrubber to cool the gas beyond

the temperature of the proper extraction of tar and lampblack in the scrubber by Lowe crude oil set?

ANSWER: It is not advisable to use cold water in contact with the hot gas in the wash box, as too violent scrubbing with cold water, while the gas is hot, is apt to condense hydro-carbons which, under proper treatment, would remain in the gas as illuminants which give candle power. It is best to have a lampblack separator so arranged that clarified warm water may be pumped from it back to the wash box, using the cold water for the first and second scrubbers. An ideal arrangement would be the gradual lowering of temperature of the gas until it reached between 60° and 70° F. at the storage holder.

ANSWER: No. But the use of too much cold water in the wash box would result in making the washer do much of the work that could be done in the scrubbers.

ANSWER: With a wash box proportionate to the amount of gas being made, it is not possible.

QUESTION: Is it not bad practice to have a steam jet exhauster between the scrubber and the purifier?

ANSWER: The principal work to be performed by the steam jet exhauster is that of ejecting gas; that is, receiving the gas at the inlet at a comparatively low pressure and, by the propulsive effect of the jet of steam increasing the pressure of the gas at the outlet. By the use of a steam jet exhauster the gas becomes saturated with water vapor, and this water vapor upon entering any piece of apparatus at a lower temperature, condenses into water and precipitates with it naphthalene and some other hydro-carbons. It is, therefore, a disadvantage to have the steam jet exhauster at the inlet of the purifiers, as such precipitation is apt to destroy the oxide of iron, and there is always a liability of naphthalene stoppages on the under side of the layer of oxide. It is better practice to have a steam jet exhauster between two scrubbers, thereby condensing the steam in the second scrubber without diminishing in any way the effect of the exhauster for forcing the gas through the purifiers.

QUESTION: What would be the effect of placing steam exhaust between wash box and scrubber in the Lowe crude oil gas set?

ANSWER: It would saturate the light particles of lampblack that escape the washer, but would result in stopping up the pipe very quickly. I think it would not affect the gas in any way.

ANSWER: It would cause a deposit of naphthalene and lampblack in the scrubber.

QUESTION: What should be the cubical contents of ordinary cylindrical scrubbers per 1000 cubic feet of gas from 25,000 cubic feet maximum make per twenty-four hours?

ANSWER: The size of scrubbers for a crude oil gas plant does not depend upon the gas made in twenty-four hours, but upon the gas made during one hour. To be more nearly correct, I should say it depends upon the gas made per minute during the time of actual gas generation. For practical purposes, however, the hourly make during actual operation is a satisfactory basis for estimation, and I should say that a minimum of 80 cubic feet per 1000 cubic feet of gas made per hour would be a safe rule.

ANSWER: There should be three scrubbers, each of which has the same cubic contents as the actual cubic contents of the generator, inside the brick lining.

QUESTION: If it were possible not to burn any of the oil to lampblack when making gas in the Lowe process, how much more gas would ten gallons of oil yield?

ANSWER: The making of lampblack in the oil gas process is an advantage, as the crude lampblack is worth more per ton for any purpose than the original oil costs. The incandescent lampblack in the superheater and generator yields a small quantity of carbonic oxide when brought into contact with dry steam. If ten gallons of oil is used for making gas, the oil weighs eighty-one pounds, the gas derived from this oil weighs about thirty-four pounds, and the lampblack produced weighs about thirty pounds, so that only seventeen pounds of oil is used for heating the machine. It will be seen at once that the process is much more economical than any coal or water gas method of making gas, and while it is not possible to burn the oil without obtaining lampblack, and it would not be desirable were it possible, the diluent gases, hydrogen and marsh gas are obtained by the destructive distillation of the oil, leaving the lampblack, which is almost pure carbon, as a by-product.

QUESTION: Which would be more advisable and economical: to put in a relief holder, or duplicate the generator in a Lowe crude oil water gas set with a 30,000-foot holder; plant running above holder capacity?

ANSWER: It would be economical to put in a relief holder for good clean gas and good results per thousand cubic feet of gas made; but, from the standpoint of safety against shutdowns for repairs, duplicate the gas generating apparatus.

ANSWER: Since your plant is running above holder capacity, the installation of a relief holder would be the more desirable and, in the end, economical. The best practice, of course, would be the installing of both the generator and holder. If the 30,000-foot holder is large enough to meet all requirements, except when it is necessary to repair the generator, and the matter of future increase is not considered, then the duplicate generator should meet requirements and would be the most economical to install.

QUESTION: Is an installation of two relief holders as satisfactory for measuring gas as a station meter?

ANSWER: If the gas is properly cooled before entering the relief holder, yes.

QUESTION: Is an excessive blast pressure (above 12" to 14" of water column) desirable in crude oil gas making?

ANSWER: In large units of the Lowe type, where the blast passes through the machine in the opposite direction from that of the gas, I have seen cases where a heavy blast (28" water column) was beneficial in blowing out the particles of carbon between runs. I believe, however, that a large volume of air at the lower pressure is better for most types of oil gas machines, if they are handled with proper care. This gives a more uniform heat throughout the machine, avoiding local hot spots.

QUESTION: Raw gas leaving the washers on the way to the relief holder is of a dark-brown color, but after standing awhile in the holder becomes clear. What is this color and what becomes of it?

ANSWER: The brown color of raw gas is due to the presence of vapors—watery and tarry. In short, the gas contains a fog of moisture and tar; when the dew point is reached, precipitation occurs. As it has been aptly remarked, "It rains in the holder."

ANSWER: This brown color is due to suspended tarry matter in a state of extremely fine subdivision. Tar formed in retorts or machines is precipitated as the gas is cooled, condensers and scrubbers removing the larger drops; the finest particles can only be removed by contact with solid bodies, for instance, by repeatedly passing through fine orifices and baffling against plates. These finer particles settle out of the gas on standing, and accumulate below the water in holder pit. Tar, thus recovered, is black, thin, and contains more oil and naphthalene, and less pitch, than condenser tar, but is usually rich in free carbon. The accumulation is extremely slow.

QUESTION: In pumping gas from a relief holder to a storage holder in crude oil gas making, is there any choice between a positive exhauster of the type made by the Root Co., and the Connersville Blower Co., and the fan exhauster such as that made by Sturtevant?

ANSWER: I have seen a positive exhauster stopped absolutely solid so that it was necessary to take off the sides to cut away deposits of hard asphalt. This could not happen with a fan exhauster, from the nature of its construction. I, therefore, prefer the fan exhauster.

QUESTION: If compressed air is used for testing pipe and fittings in distributing systems which are operated at a maximum of 15 pounds, what pressure will give a most satisfactory test?

ANSWER: From forty to fifty pounds pressure. Leaks which develop under the operating pressure will show up at forty to fifty pounds, while this test pressure will not unduly strain and weaken either the pipe or the fittings.

ANSWER: My experience is that 100 pounds would be the most satisfactory test.

ANSWER: Sixty pounds air pressure.

QUESTION: Would like to know if pressure blowers (Sturtevant type) are used in water gas plants; if not, state reason.

ANSWER: So far as I know, there has been no demand for a blast pressure in excess of that delivered by the "Sturtevant Monogram Blower," in the double superheater water gas process.

ANSWER: Pressure blowers of the "Sturtevant type" are not generally used in water gas plants, the object of a blower in a water gas plant being to secure as large a volume of air as may be necessary with such pressure as the conditions of generator fuel bed calls for, a moderation of the so-called volume blower has been found best adapted to water gas purposes.

Under certain conditions of operating I believe a pressure blower could be used to advantage. For example, where anthracite coal, such as was used on the Coast some years back, particularly Welsh anthracite coal, a heavy pressure is required to force the air through the fuel bed, and while great volume would be required here, a heavy pressure is also necessary, consequently under these conditions a larger pressure blower would be preferred to the usually smaller volume blower. Where coke or an anthracite coal, more homogeneous than the Welsh is used, a modification of the volume blower would be preferred, the object being, as stated, to obtain a large volume of air under moderate pressure with a minimum expense of power.

QUESTION: What is the best method of testing pipe and fittings for a distributing system which is to operate a maximum of 15 pounds?

ANSWER: Dry compressed air. Pipe and fittings, which show no leaks under test with water or other liquids, in many cases will not prove tight when tested with five pounds air pressure.

ANSWER: I would say "compressed air."

ANSWER: Test each length of pipe separately before placing in the ditch. Two hundred pounds kerosene oil is a good test for this purpose. Test each fitting to at least sixty pounds air pressure, and apply soap and water to the entire surface. Sand holes are numerous. After pipe is made up in the ditch, test to at least sixty pounds, air pressure, and apply soap and water mixture to joints before back-filling ditch. If possible, allow pressure to stand for several hours before back-filling, as the test will be more satisfactory by so doing.

QUESTION: why does the presence of a trace of unsaturated hydro-carbons inhibit the reaction between phosphorus and oxygen?

ANSWER: This phenomenon seems not to have been explained up to the present time, although it has been long known that traces of certain hydro-carbons, notably ethylene, prevent the reaction between phosphorus and oxygen. I quote the following from Winkler & Lunge, Technical Gas Analysis, 1904 edition, page 69:

"The presence of certain gases and vapors retards or even stops, in a hitherto unexplained way, the oxidizing action of oxygen on phosphorus. Perhaps this phenomenon is of a similar kind to the 'paralyzing' action of minute quantities of hydrogen sulphide, carbon disulphide, and other foreign substances upon the catalytic action of platinum and of organic ferments, as observed by Bredig and Muller von Berneck (Zsch. f. physik. Chem. 1899, p. 324).

"Among the substances interfering with the absorption of oxygen by phosphorus are, according to Davy, Graham, and Vogel, hydrogen phosphide, hydrogen sulphide, sulphur dioxide, carbon disulphide, iodine, bromine, chlorine, nitrogen peroxide, ethylene, acetylene, ether, alcohol, petroleum, oil of turpentine, eupion, creosote, benzene, tar, and many essential oils. How strong this influence may be, is shown by the fact that as little as 1/1000 vol PH_3, 1/100 vol. C_2H_4 1/4444 vol. oil of turpentine suffices for making phosphorus and oxygen indifferent to each other. Hence, the application of phosphorus as an absorbent for oxygen is restricted, and is excluded in all cases where the presence of such disturbing substances is to be assumed with any degree of certainty. But, according to experiments made by O. Brunck, at Freiburg, these substances can, in most practically occurring cases, be removed by a previous treatment of the gas with fuming sulphuric acid, so that this enables the analyses of illuminating gas and that of fire damp to be made by that means. This proves the incorrectness of the assumption hitherto held, according to which methane and ethane belong to the class of interfering sub-

stances, as these are not removed by the treatment with fuming sulphuric acid.

"The method in question renders excellent service in the examination of air, of chimney gas, vitriol-chamber gases, etc.; for, generally speaking, phosphorus is superior as to certainty and speed of action to every other reagent for the absorption of oxygen. Lindemann (Zsch. f, Analyt. Chem., 1879, p. 158) has greatly facilitated the practical use of this reagent by the construction of a special absorbing apparatus."

ANSWER: It has long been known that phosphorus has an affinity for hydro-carbons, and this affinity appears to be greater between phosphorus and unsaturated hydro-carbons than between phosphorus and oxygen. In general, hydrogen is more easily dissociated from its compounds than heavier gases from their compounds. It is also a chemical truth that in any group of three compounds, one of which is capable of combining with either one of the other two, there will be a selective preference.

In taking up oxygen, phosphorus is compelled to break up the molecules of oxygen to form either P_2O_3 (phosphorus anhydride) or P_2O_5 (phosphoric anhydride), while an unsaturated hydro-carbon might give up its hydrogen easily to the phosphorus to form PH_3 (phosphene). The following results were obtained from a gas known to contain not to exceed two per cent. of oxygen. The gas was passed into the potassium hydrate pipette, and three and five-tenths per cent. of carbon dioxide was extracted. After this, the gas was passed directly into the pipette containing phosphorus, with the following results:

After 25 minutes	.7% loss
After 57 minutes	.8% loss
After 2 hours, 27 minutes	.8% loss
After 4 hours, 27 minutes	.9% loss
Making a total of	3.2% loss

by exposure to phosphorus. I believe that phosphorus combined with the hydrogen of the unsaturated hydro-carbons to form phosphene in preference to breaking up the oxygen molecules.

QUESTION: Oxide, after being used one or two years and is then thrown out into the atmosphere and exposed to the sun and air for another year or so, appears to be thoroughly revivified. Can this same oxide be used again?

ANSWER: Oxide of iron properly used is only required to purify gas that has been previously freed from all tarry matter, oil, vapor in suspension or, in the case of coal gas, of ammonia. When great care is used, the only limit to the life of oxide of iron is the percentage of free sulphur which it contains. This may reach as high as sixty per cent. before the the purifying action of the oxide is so weakened as to make it necessary to renew it. In many cases, where oxide of iron is removed from purifiers as spent oxide, its usefulness as a purifying material has been destroyed by the tar and oil. Such oxide, upon being exposed to the air and rain, will become cleansed and assume the reddish color of new oxide. This work, performed by the elements, may be accomplished in a few hours by washing the oxide with lime water while still in the purifier. The only reliable test to determine when oxide of iron is unfit for use, is to determine the amount of free sulphur contained in it. This is done by washing out the sulphur in a weighed sample of oxide by means of carbon disulphide. An inexpensive apparatus used for washing grease from wool, is the simplest and best means of dissolving out the sulphur.

QUESTION: Are there any gas retorts made from other materials than iron or fire clay that are a success?

ANSWER: I know of no gas retorts made from other materials than iron or fire clay that are a success. Of course, there are sometimes materials other than fire clay added in the manufacture of gas retorts. Some manufacturers add a certain proportion of pure silica, the fire clay, which is mixed with it, acting as a binder; but these retorts are known as fire clay retorts. As a rule, high-grade fire clay contains sufficient amount of free silica in its composition, so that pure silica does not have to be added, and it is very difficult to add pure silica in proper proportion to form as good retorts as where it is originally contained in the composition of the fire clay coming from the mine.

QUESTION: What has been found best for tees and crosses on high pressure pipe lines?

ANSWER: Those constructed after the "Dresser Idea," because the ordinary fitting does not admit of the force used on the line socket in screwing up.

QUESTION: What has proven in practice the best and most economical coupling for high pressure pipe lines, all things considered?

ANSWER: "The line socket or coupling" with beeswax and tallow mixed as a lubricant, using a power winch for setting up joints instead of pipe tongs or wrench devices, expanding the joint by friction, thereby concealing the threaded ends within the joint, making a strong, durable and tight coupling and a time economizer in installation, and consequent dividend winner by preventing the loss of a marketable commodity.

QUESTION: What is the proper way by which to designate the openings of reducing tees and crosses so that no mistake can arise in ordering such fittings?

ANSWER: In ordering reducing tees, it becomes necessary to name the run and outlet. Figure 1 illustrates diagrammatically the run and outlet and shows the tee reducing on the outlet. Such a tee is read 2x1½ inches. The run is read first.

FIG. 1

FIG 2

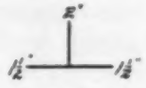


FIG 3

FIG. 4

FIG 5

In ordering tees that reduce on the run, we say 2x1½x1¼ inches, as shown in figure 2. Whenever both ends of the run are of the same size, but having the outlet larger, such a tee is called bull-head and is read 1½x2 inches, as shown in figure 3. It will be seen that when a tee reduces on the run, we will have three figures to specify; whereas, if a tee reduces on the outlet, we have but two figures to indicate. Thus, in tees reducing on the run, we have ½x⅜x½ inches; reducing an outlet, we have 1x¾ inches.

In like manner, in ordering crosses, we must be particular about stating the size of outlet or run. A very important rule about crosses is as follows: The outlets of a cross are always of the same size, and indicated by the last figures. By referring to figure 4, it will be seen that the outlets are two inches, while the run is three inches; but, since the outlets of a cross are always of the same size, it follows that a reducing cross must reduce on the run. A cross 1½x1¼x1 inch, shows the outlets are one inch, while the run is 1½x1¼ inches. It should be remembered that crosses are read on the run first and, when reducing on the run, we have three figures to mention; when reducing on the outlets we have two figures to indicate.

QUESTION: Is it common practice to use leveling instrument in grading the bottom of pipe trenches to secure an even surface for pipe to rest upon?

ANSWER: As a matter of observation, generally the bottoms of trenches do not receive the attention they deserve in harmony with good work, and many leaks are due to settling strains, while otherwise the pipe has been well put together. A wholesome supervision is needed over this branch of installation that is generally overlooked, to the company's detriment.

QUESTION: What materials other than lead or cement can be used to connect the ordinary cast bell and spigot joints together so as to make a pipe-line gas tight?

ANSWER: Iron borings and sal ammoniac (called rust joints) have been used, but are now discontinued. Sulphur also has been used, but in many instances it has split the sockets of the pipe. A new material, called leadite, is now used to some extent. This material melts at about 400° F., and is poured into the sockets as thin as oil. The joint is made in the ordinary way, first caulking in the yarn and then pouring in the leadite. A four-inch joint requires about two and one-half pounds of leadite. The advantages claimed for this substance are that it makes a tight joint without caulking, and will withstand a pressure as high as 100 pounds to the square inch.

ANSWER: In my experience, covering nearly forty years, I have not seen any material used, either by myself or others, in connecting ordinary cast-iron bell and spigot pipe but Portland cement or soft lead. In fact, I am inclined to rule out the Portland cement, as the space allowed for cement in ordinary cast-iron pipe is not usually sufficient to allow a proper joint to be made. If it were designed to use Portland cement on a pipe line to be gas-tight, the alteration could be made in the bells when ordering the pipe.

QUESTION: Which is better for pipe joints: graphite and boiled oil, or red lead and oil?

ANSWER: The material used for making pipe joints depends entirely upon the purpose for which the pipe is to be used. For pipe joints intended for low pressure gas, where the joints are to be broken from time to time, graphite and boiled oil is good. If the joint is to be made for low pressure work, and will not be disturbed, red lead and oil is good. Pipe joints on oil lines should be made with copal varnish. This forms a glassy joint which is permanent and is impervious to all kinds of oil including the naphthas. Brown soap is also used for screw joints for oil pipes. Another good oil joint is black oxide of manganese finely ground and mixed with orange shellac. Alcohol is used for thinning this preparation, and when this joint is made the shellac sets quickly and the joint should not be disturbed. This also applies to copal varnish joints. For high pressure steam joints, Smooth-on packing gives excellent satisfaction.

ANSWER: Red lead, for a great many years past, has been used almost exclusively by pipe fitters for making up joints. It sets readily and makes a hard, durable joint and is a protection to the metal. Graphite and oil makes a tight joint for some purposes, and is easily taken apart. For all-around work, I think red lead and oil is the best.

ANSWER: My experience is that red lead and boiled oil makes the best joint.

QUESTION: 1. Under what conditions would you place a prepayment meter?

2. Is not the chance of the attachment becoming useless as great as that the consumer will repudiate the bill?

ANSWER: 1. Often, by request of the consumer, especially where gas stoves are in use. As with some, the sight of a gas bill stops digestion, creates a dyspeptic, and a consequent growler, to the detriment of the gas company. Pleasant relations between collector and consumer are always desirable.

2. Most decidedly not. On the other hand, collections are often times increased from two to four-fold from the improvident who are unmindful of collection day, but do slip in the necessary quarters in the prepayment meter. Also, the pessimistic customer is in a great measure deprived of his expletives about robbing corporations and thieving monopolies. His collections are made more pleasant by the company's representative. Fault, if any, is in making the cash received compare with the gas statement turned in, for in many cases the consumer places in the magazine the limit ($2.50) when in reality he has consumed, say, fifty cents' worth of gas by the time the statement is taken, or in other words has paid in advance, so in that way bothers the bookkeeper while benefiting the company by an increase of revenue.

2. A remedy for this has been suggested by one of our members who has instructed his collectors to remove from the prepayment meter only the amount of money actually due the company for gas consumed, leaving in the meter any excess of coin which belongs to the consumer until its value in gas has been registered by the meter.

ANSWER: 1. Whenever a prospective consumer demanded one, when consumers gave much trouble in collecting account, when there were frequent changes of tenant in flats.

ANSWER: 2. There should be no chance for the attachment to become useless, unless tampered with for the purpose of "beating the meter," consequently the consumer cannot consistently repudiate the bill; and, if he did, it would not avail him, as we would collect the difference between the cash in the box and the reading of the meter, or cut off the supply.

ANSWER: 1. If no deposit is exacted, then in premises where tenants are frequently changing or when requested by consumer. If deposit is exacted, then when requested by consumer.

ANSWER: Another answer suggesting a most valuable use for the prepayment meter reminds us of Pas Partout in the old story of "Around the World in Eighty Days." Many families close up their houses in the summer time, preparatory to leaving for the country. All are in the hack, ready for the start. Some necessary article is forgotten, house is re-entered and, on account of darkened rooms, the gas is lit. The article

is found, time is limited to catch the train. Gas forgotten, house locked, curtains down, blinds closed, trip begins for a three months' vacation. With a prepayment meter, the gas company requires no mortgage on the house to secure payment for gas consumed during days and nights of that vacation. The prepayment meter faithfully guards the interests of both by extinguishing the light in due time, and the Consumer and gas company remain friends.

QUESTION: Is there any way to stop or reduce vibration on high pressure regulators? Where the initial pressure in the gas main is from fifteen pounds to twenty pounds, the regulator vibrates when using the gas and rattles so badly as to make a very disagreeable noise.

ANSWER: I did a little experimenting to get a valve to vibrate, but was unsuccessful. I loosened the valve seat, changed the amount of gas going through, put water in the inlet, and did everything I could think of to make it vibrate, but was unable to do so. I had two complaints of this kind about a year ago. I had the governor changed in each case, which stopped the trouble. The valve seat being loose is the only reason to which I can attribute the cause of vibrating, as I used to have the same trouble with some compression faucets in the plumbing business, and a loose seat was the cause of their working the same way.

ANSWER: A dash pot on valve stem, arranged to retard the motion of valve, will usually stop pulsation. This is sometimes done with a loose-fitting piston moving in a cylinder filled with oil, also by throttling the flow of fluid to the controlling diaphragm.

QUESTION: Are free services to the property line a success?

ANSWER: Free services to the property line must be a partial success, but all gas companies should provide free services from their mains to the meters with free meter connections in order to give their customers the ordinary service supplied by tradesmen, where the smallest parcels are delivered promptly and without charge to the most remote parts of cities. Milkmen would find little demand for their commodity if the customers were compelled to furnish the cans for its delivery, and gas companies should not expect to sell gas and satisfy its consumers until they deliver their commodity through a good size service pipe and a meter amply large to measure the gas without pulsation.

ANSWER: My answer is yes. In fact, I would say that free services from main to meter are a success.

ANSWER: The general custom of laying services to the property line without charge has not proved the success contemplated, and is not considered an inducement by prospective consumers. Especially is this conclusion justified by those residing in rented houses, who are not disposed to pay for improvements on property not owned by themselves. I have observed that many companies are selling gas ranges at cost and less than cost; they had far better lay services free, thus placing the means of using gas, selling ranges at a fair profit, and by small monthly installments, which we have demonstrated to be a great success, as we are increasing at the rate of nearly 100 (to be exact, 98) consumers per month since March of this year. Our increase this month of thirty-two per cent. gas used by consumers' meters over the corresponding month of last year, I ascribe largely to free services to those living in rented houses, and I heartily commend the plan as a splendid investment for gas companies, especially where it is desirable to increase the day send-out.

QUESTION: Does a diminished flow of gas, due to trapped service, increase a consumer's gas bill?

ANSWER: Not directly, but owing to the inefficiency of gas burners for lighting, and stove burners, the consumer usually lights many more burners than would be necessary if the service were satisfactory, with the result that the consumer's bill is increased by the multiplicity of smaller flames. It is also true that low pressure on a gas stove requiring a greater amount of time to perform a given amount of work, is wasteful.

ANSWER: Will say, at first glance, yes. Reducing the flow of gas will take longer to do the same work, during which time the efficiency of the reduced flame will not be as high while a given article is being cooked. In practice, I would say that a reduced pressure at the gas stove burner from any cause will not increase the consumer's gas bill; in fact, I believe it is a common mistake in practice for most people to use too much gas while cooking. The frying pan, the oven and broiler need a good pressure and a brisk, hot flame for their work; and, unless a good pressure and supply of gas is given these burners, the cakes, biscuit and bread will be bought at the baker's, close by, and the head of the house will try and get along with stewed beefsteak until a post mortem is made by the gas company. In conclusion, I would say that wherever the flow of gas is diminished, from any cause, an indifferent amount of cooking is done, and the consumer's bills will be less.

ANSWER: No and yes. If a consumer used gas for lighting with open tips, a trapped service will make no difference in his bill; but, if gas is used for cooking, you cannot get as good results with a poor service, due either to a service being trapped, or a partial stoppage from other causes. The amount of differences depends altogether on the condition of the service and the pressure it will maintain when in use.

QUESTION: A consumer claims he has greatly reduced his gas bills by raising the burners on his range to make a shorter flame. Is there not a point worth considering here? and should burners of different size all have the same space between them and the cooking utensils?

ANSWER: I would state that, in my opinion, the distance between an ordinary hot-plate or range burner and the utensil, should be one and one-quarter inches; between the giant burner and the utensil, one and one-half inches, and between the simmer and utensil, one inch; and for all other sizes in like proportion. The distances mentioned allow for the proper combustion, and should not be varied.

ANSWER: I think that if a stove is properly adjusted to suit the pressure of the gas supply, it will be found that the burners of a first-class gas range are set about right. The space between the cooking utensil and burner is figured at a certain pressure by stove manufacturers; any variation from this pressure will necessitate the changing of the gas inlet and air mixer. If the gas pressure is exceptionally low, it may be advisable to raise the burners a little.

ANSWER: The burner on a gas range being what is known as a Bunsen burner, has, as do all Bunsen burners when properly adjusted, a zone of intensest heat, and, it seems to me, that if this point of the flame could be applied to the utensil, the best results would be obtained. As this zone of

intense heat, or, in other words, the height of the Bunsen flame, would vary with the different pressure under which the gas is delivered to the Bunsen, and also vary with the different quality of gas, as well as in the different kinds of gas, in order to meet the requirements under these different conditions, a burner would have to be so made that it could be raised and lowered as desired, which would complicate the construction of the range top so as to be beyond the understanding of the average consumer, and it would be difficult for the manufacturer to adjust burners to a height to meet these different requirements, as this would necessitate a complete stock of ranges for each variety of gas used.

The gas stove manufacturers adjust their burners, so far as possible, for local conditions, making burners adapted for coal gas, water gas, oil gas, or natural gas, and will, if given the necessary data, adjust their burners to any pressure desired. As pressure, however, on any system, with the possible exception of high pressure systems, is variable as to length of line and elevation, no gas company can state just what pressure they desire the burners adapted for. It has, therefore, been customary for manufacturers to place their burners at a height to conform to average conditions, and they will probably be compelled to do so until all gas companies, or the majority of them, adopt the high pressure system for distribution with regulators reducing to a standard house pressure.

QUESTION: What effect is there on the atmosphere of the room from water in pan under the burner of the Baccus and similar grates?

ANSWER: The heat from the burner produces sufficient vapor to moisten the atmosphere without which the air would be dry and the heat oppressive.

QUESTION: What is the most satisfactory radius for pipe bends?

ANSWER: In laying out piping equipments, the dimensions given below will be found satisfactory, and can be obtained more promptly than where other radii are used:

Size of bend—Inches	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Radii recommended—Inches	12½	15	17½	20	22½	25	30	35	40	45	50	60	70	75	80	108	120	132	144
Shortest length of straight pipe necessary on each end—Inches	4	4	5	5	6	6	7	8	9	11	12	14	16	16	20	22	24	28	32

QUESTION: Given the analysis of an illuminating gas, how may one determine its specific gravity?

ANSWER: Multiply the volume percentage of each constituent by its respective specific gravity, add the products, and the sum divided by 100 will be the specific gravity. The illuminants must be calculated as ethylene. The reason for dividing by 100 is obvious.

Gas	Per Cents		Sp. Gravity (Air=1000)		
CO_2	5.0	×	1.529	=	7.645
C_nH_{2n}	10.0	×	.9674	=	.9674
O_2	0.1	×	1.1056	=	.11056
CO	25.0	×	.9674	=	24.18500
H_2	33.9	×	.06926	=	2.347914
CH_4	20.0	×	.556	=	11.120000
N_2	6.0	×	.97137	=	5.828220
	100.0				60.910694 ÷ 100 = .609

QUESTION: What has been the experience with steam turbines in connection with blowers for gas making? Also, has the Sirocco blower, made by Davidson, of Belfast, Ireland, been successfully used for water or crude oil gas making?

ANSWER: The European De Laval Companies have been active in developing turbine driven blowers adapted for gas making, particularly the French De Laval Company, who were the first of the European branches to manufacture blower units for pressures as high as 21-inch water gage.

The De Laval Steam Turbine Company, of Trenton, New Jersey, has been manufacturing turbine driven blowers for the past four years. On account of the construction of the steam turbine in sizes up to and including fifty-five-horsepower, a single blower casing with one wheel is used for direct connection. This turbine blower is usually of the Sturtevant monogram and high pressure type, or the Sirocco fan.

The steam turbine is very well adapted for driving blowers on account of the high speed obtainable. The smallest blower used is the No. 3 Sturtevant Monogram, driven by a seven-horsepower turbine. This machine operates at 3000 revolutions per minute, and discharges 3681 cubic feet of free air per minute against a pressure of 5.19 inches water gauge.

Any one of the following six sizes of Turbines can be connected to one of four different sizes of Sturtevants blowers, the quantity of air and pressure desired determining the proper size.

This makes a total of twenty-four combinations giving pressures ranging from 3681 cubic feet per minute at 5.19 inches, or 1058 cubic feet against 21.62 inches up to 16,108 cubic feet against 5.19 inches, or 7995 cubic feet against 21.62 inches.

The blower can be furnished with any direction of blast, and in various sizes of openings. Gas exhausters of the Sturtevant type are also manufactured, being designed to discharge gas or air against the pressures usually required in transferring gas from one point to another.

These blower units are all finished complete and tested in the shop of the De Laval Steam Turbine Company before shipment is made, and in many cases, where the destination is not too distant, and when the purchaser so desires, an experienced operator is sent to see that the machine is properly installed, and that the operating force of the gas works are made thoroughly familiar with the proper method of operation of the turbine. Very little trouble has been experienced where this has been done, but like all other machinery on the market, not widely known by the ordinary type of operating engineer, many cases of carelessness in erection have been experienced by the De Laval Co., where men who knew nothing of the turbine were entrusted to set up the machine for use.

When the turbine and blower are set on a level foundation, which need not be heavy, and steam and exhaust connections have been made, the unit is ready for operation; all that is necessary for the operator to do is to see that all of the bearings are kept clean and freely oiled. The amount of oil used in the bearings does not mean, necessarily, oil lost; because, after passing through the bearings, the oil returns to a tank at the bottom of the machine, where it can be drained for use again after filtering. The unit should be level accurately, and care should be taken in bolting the framework to the foun-

dation least it be pulled out of alignment, in which case the bearings would be likely to give trouble.

In operating the blowers in connection with water gas apparatus where seven-minute or longer runs are made, it is advisable to keep the turbine at about two-third speed between runs, so that when the full blast is required the turbine can be brought to speed without unnecessary shock. The amount of steam consumed during the intervals when blast is not needed is very small, and there is the advantage of having the oil system always ready.

An oil reservoir can be connected at any convenient point on side wall of the building from which it may be piped to the turbine and fed to the bearings through small brass pipes controlled by individual cocks. The slow speed shaft of the unit are all ring oilers, and require no more attention than occasional draining and replenishing of new oil.

In sizes above fifty-five-horsepower, the De Laval Company usually connect to Sirocco blowers, using two blowers for each unit, mounting them on a single bed plate staggered, which method is necessary on account of the turbine having a reducing gear on each side of the turbine shaft.

The Sturtevant Company is now developing a line of blowers in sizes suitable for direct connection, the same as those of the Sirocco type, some changes in diameter of casing being necessary to accomplish this.

The largest blower manufactured is a 300-horsepower turbine direct connected to two sixty-inch Sirocco blowers, having a capacity of 42,000 cubic feet per minute against a pressure of twenty-one-inch water gauge. This unit was recently installed at the plant of the Laclede Gas Company of St. Louis. Only 225 horsepower is now used, but provision is made for an increase in capacity.

There is absolutely no difference in operation of the Sirocco Blower from that of the Sturtevant type, the efficiency of each is about the same, and in some cases one may be slightly higher than the other.

QUESTION: What has been the experience with steam turbines in connection with blowers for gas making?

ANSWER: Tests conducted by Commander A. B. Canaga, Lieutenant H. C. Dinger and Ernest N. Jansen of the United States Navy, on a Sirocco Blower designed for service in the navy, are reported in a recent issue of the Journal of the American Society of Naval Engineers.

The blower was to supply 56,000 cubic feet of air per minute at a pressure of five and a half inches of water. It was of the "Sirocco" type of encased fan twenty inches in diameter, having a double inlet, discharging on the side and mounted on a common bedplate with the turbine. The width of the fan was twenty-four inches and when delivering 33,170 feet of air per minute in the first test it revolved at 1,500 revolutions per minute. At this speed the air horsepower developed was 34.45 and the brake horsepower 63.54, the corresponding steam consumptions being 42.09 and 22.8 pounds per horsepower hour, respectively. This is figured on a fan efficiency of 54.2 as derived from the test. The steam pressure at the nozzles in the above test was 164 pounds, with a temperature of 386.5 degrees Fahrenheit and a vacuum of 25.84 inches. In a test run at less speed, the quantity of air delivered was 22,230 cubic feet per minute at 1,000 revolutions per minute. The brake horsepower at this speed was 22.98 and the air horsepower 10.81, so that the efficiency was 47.05 per cent. With steam at 166 pounds pressure and 370 degrees Fahrenheit, and a vacuum of 26 3-8 inches, the steam consumption was 58.28 pounds per air horsepower hour. The temperature of steam corresponding to a pressure of 164 pounds is 372 degrees, so that the steam entering the turbine was superheated about 14.5 degrees in the first test and in the last only two degrees. The steam consumption was calculated from the known discharge of a De Laval nozzle under the same steam conditions as existed in the test.

QUESTION: Can a gas company garnishee a consumer's wages for a gas bill?

ANSWER: In this State the plaintiff may have an attachment or garnishment issued against the defendant, when the cause of action arises upon a contract, express or implied, for the direct payment of money:

Code of Civil Procedure, Sec. 537, subd. 1; (Superior Court); Code of Civil Procedure, Sec. 866; (Justices' Court).

An action for money due for gas comes within these sections.

The question of the exemption of the wages of the judgment debtor is of importance in determining whether or not an attachment or garnishment of his wages can be made to hold.

It is provided in the Code of Civil Procedure, Sec. 690, subd. 10 that:

"The following property is exempt from execution (and, of course from attachment) except as herein otherwise specially provided:

10. The earnings of the judgment debtor for his personal services rendered at any time within thirty days next preceding the levy of execution or attachment, when it appears, by the debtor's affidavit or otherwise, that such earnings are necessary for the use of his family, residing in this State, supported in whole or in part by his labor, but where debts are incurred by any such person, or his wife or family, for the common necessaries of life, or have been incurred at a time when debtor had no family, residing in this State, supported in whole or in part by his labor, the one-half of such earnings above mentioned is nevertheless subject to execution, garnishment or attachment to satisfy debts so incurred."

Therefore if the debtor have no family in this State depending upon his labor, the entire amount of his salary would be subject to garnishment for a gas bill; if, however, he have a family within the State dependent upon his labor, one-half of his wages for services rendered at any time within the preceding thirty days is, nevertheless liable therefore if gas, either for light or fuel purposes, be regarded as a common necessary of life. While no decision has been found holding that gas as so used is necessary, there can hardly be any doubt that if the question should arise it would be so considered, and therefore attachable to the extent of one-half of the debtor's wages for the preceding month.

QUESTION: Should managers of telephone companies be discouraged in the common practice of grounding on gas fixtures and gas piping?

ANSWER: The current used in telephone practice is of the weakest nature, and besides being alternating in its character, removes all danger of electrolysis in the pipes. It might be argued that heavy lighting circuits could become crossed outside with the telephone wires and thus bring dangerous current to the gas pipes, but for their own protection telephone companies effectually guard against this by fusing devices.

The danger of a "jump spark" sufficient to ignite gas is exceedingly remote and could only take place under the most peculiar circumstances. The efficient ground connection that a gas or water pipe affords the telephone manager is a great convenience to him and is of benefit to his service and need not worry the gas man.

ANSWER: I see no objection to grounding telephone wires on gas piping so far as the gas man is concerned, that is if the ground is properly made. I do not think the plan of grounding on gas fixtures a good one for oft times gas fixtures hang from insulating joints. I can not think of any case where it would be detrimental to the gas man to have the ground on his pipes. The trouble, if any there was, would accrue to the telephone man by reason of removing meters, etc., which would cut his ground off.

QUESTION: Which incandescent gas burner, including the various gas arcs is most profitable to the gas company and satisfactory to the consumers, taking into consideration the care required to maintain the burners in good condition while charging all renewals of mantles and chimneys to the consumer?

*Note. This question has not been answered, probably on account of thrusting too much commercialism into a gas convention, and perhaps with the fear of doing injustice to some particular burner, and I would suggest that the subject of incandescent burners covered by the above question be freely discussed, and that the question and discussion be eliminated from the minutes of the meeting.

QUESTION: How can the production of naphthalene be avoided?

ANSWER: This question has been asked and answered in the Question Box of probably every gas association in existence to-day, and it seems to me it has resolved itself into a matter of opinion and local experience. I will consider it in connection with crude oil gas only, such as we make on the Pacific Coast. I do not think the production of naphthalene can be avoided. It is always in that part of the gas which we call iluminants. It is possible, however, to vary the proportion of naphthalene to the other illuminants, by changing the heats in the generating apparatus.

This question then resolves itself into how can naphthalene troubles be avoided?

By having service pipes large enough (not less than one and a quarter inches for one consumer) and by careful operation of generating apparatus keep the gas uniform in composition.

The production of naphthalene is the result of the refinemeent of the gas making process, during the last twenty-five years. Higher heats and greater yields in coal gas making produces naphthalene, and higher heats together with intense local heat in generators or superheaters produces it. Naphthalene production may be avoided by lowering the temperature of the generating apparatus, but it is a question whether the troubles which come from naphthalene deposits are not more than offset by the greater illuminating power of the gas, for naphthalene is one of the best of the illuminants. In several of the English gas works, naphthalene is being washed from the gas by means of anthracene oil, and there is a patented process for accomplishing this result. This method of removing naphthalene would be practically prohibitive in a locality where there are no coal tar products, and it would be necessary to import anthracene oil at great expense. Careful management of the heats and the distribution of the gas through pipes of ample size together with precautionary measures against sudden shocks, either mechanical, which would include sharp bends, or sudden reductions in size; or physical, by sudden changes in temperature where the gas is carried through pipes passing from hot to cold places, or vice versa. A sudden rise in temperature seems to deposit as much naphthalene as a corresponding fall in temperature. For instance, where a service pipe passes from the ground into a hot cellar.

QUESTION: What is the best method of handling naphthalene stoppages?

ANSWER: Plenty of boiling hot water followed by about a pint of gasoline, depending on the size of the service.

ANSWER:

NOTES ON NAPHTHALENE.

Naphthalene is slightly soluble in hot water (Leffmann), sparingly soluble in cold alcohol, easily soluble in boiling alcohol, from which it crystallizes in plates and scales. Soluble in methyl alcohol, from which it crystallizes. Soluble in gasoline cold, more easily hot. Soluble in benzine (Petroleum naptha), freely in the cold, more readily in hot, from which it crystallizes in beautiful glistening needles, and sometimes crosses with mitred joints. Most freely soluble in benzine (C_6H_6) from which it crystallizes white, snowy and rather amorphous.

Gas containing naphthalene causes a floculent, or rather a curdy precipitate with an aqueous solution of picric acid. This precipitate does not resemble naphthalene in appearance, but the precipitate dissolves by shaking with benzine (petroleum naphtha), and it remains in solution in this liquid. A single small crystal of naphthalene dissolved in cold alcohol will produce the same floculent precipitate upon the addition of picric acid solution.

*In an ammoniacal atmosphere, it volatilizes more easily than in air, hydrogen, etc.

This may account for the fact that little trouble is experienced from naphthalene where a portion of the ammonia from coal gas is allowed to pass beyond the washers and go out into the distributing system.

The writer has noticed the difference in naphthalene troubles in towns where ammonia is valuable and carefully saved, and where the amount of ammonia permitted to remain in the gas is regulated by law. And towns where there is no legal restriction of the amount of ammonia permitted to remain in the gas, and where particular attention is paid to the removal of all the ammonia.

In selecting any of the above substances to dissolve naphthalene in service pipes, cost is the first consideration, and benzine (C_6H_6) and wood alcohol are the best solvents. If hot water is used for cleaning out the pipes, it is of great importance that a large quantity of very hot water is used. Its melting temperature is 174.2° Fahrenheit, so that water of temperature less than this would have nothing but a mechanical flushing effect upon the naphthalene.

ANSWER TO QUESTION No. 1: Naphthalene can best be avoided by maintaining a moderate heat in the retort instead of excessive high heats. It is generally known that excessive heats are conducive to the production of naphthalene, the vapor strength of naphthalene is high and readily changes to solid flakes without liquifying.

ANSWER TO QUESTION No. 2: I consider some of the lighter crude oils (as gasoline) very good for removing naphthalene. It depends largely at what point or place in the gas system the naphthalene troubles appear as to the best method for removing the trouble. If in the condensors, scrubbers, washers, etc., they can usually be by-passed and washed and cleaned out, also, most all connecting pipes are so arranged with hand-boles and large plug-holes so they can be cleaned out.

QUESTION: How can the production of naphthalene be avoided?

ANSWER: 1st. By carrying the lowest heats in the gas-making apparatus, *i. e.*, gasification of the hydrocarbon vapors.

2nd. By a thorough mechanical scrubbing of the gas, as exemplified in the action of the P. & A. tar extractor, by which those particles of naphthalene kept in suspension in the gas are thrown down with the rest of the tar fog and prevented fron condensing in the street mains.

3rd. By such a regulation of temperatures in the works as will keep the outlet of the storage holder at a temperature not lower than the average temperature at which gas is delivered to the consumer. It is desired to preserve as much of this valuable light-giving constituent of the gas as possible, having regard to the saturation point of the gas for the lowest temperature likely to be encountered.

4th. A careful preservation of the aromatic hydrocarbons present, or enrichment by benzol will do much to increase the carrying capacity of the gas for naphthalene.

QUESTION: What is the best method for handling naphthalene troubles?

ANSWER: 1st. On large lines, flushing with steam or hot water.

2nd. On small lines in services, dissolving out with light tar oils.

3rd. When extending all over the distributing system, lowering the heats carried in the apparatus and enriching with benzol sufficiently to not only preserve in the gas the naphthalene present, but to dissolve out that already deposited by degrees.

QUESTION: What should be the cubical contents of ordinary cylindrical scrubbers per 1000 cubic feet of gas from 25,000 cubic feet, maximum make?

ANSWER: Two hundred and twenty-five cubic feet. This would be approximately a scrubber five feet in diameter and ten feet high.

QUESTION: What difference does it make in the operation of a gas plant, if the unclean gas is stored in the holder until needed and then purified out through the boxes, instead of first purifying it into the holder and then out to the street mains?

ANSWER: On a small scale—none providing plant is built with that object in view. On a large scale—objection would appear, due to the uneven rate of purification occasioned by the heavy night output.

QUESTION: What effect is there on the atmosphere of the room from water in pan under the burner of the Backus and similar grates?

ANSWER: The effect would be two-fold. First, the water pan is in such close proximity to the flame that a considerable evaporation of the water is produced. This evaporating effect is enhanced by the arrangement of a light cast iron front plate or "lower log" across the front of the heater; the upper edge being about on a level with and very near to the flame, and the lower edge dipping into the water.

Evaporation is probably induced by a capillary action of the rough surface of the warm iron combined with the heat of the gas flame. This tends to keep the atmosphere of the room heavily charged with moisture.

Second, the gas log unquestionably causes a circulation of the atmosphere of the room. The air is then brought into more or less intimate contact with the water and vapors rising from it. This water body and vapor curtain would exercise a powerful freshening effect on the atmosphere by the absorption of impurities which rapidly accumulate when a number of persons are confined in a room without thorough ventilation. It would therefore relieve to some extent what is generally termed the "closeness" of the room.

QUESTION: Is there any way to stop or reduce vibration on high pressure regulators? Where the initial pressure in the gas main is from fifteen pounds to twenty pounds, the regulator vibrates when using the gas, and rattles so badly as to make a very disagreeable noise.

ANSWER: High-pressure regulators will not vibrate when properly constructed.

When such vibration occurs, it is due to inherent defects in the design of the regulator and cannot be stopped or reduced. The only remedy lies in a change of design so as to avoid the conditions which invariably produce the effect complained of.

A regulator which vibrates under any of the ordinary conditions of usage should not be tolerated by the gas companies. It should act silently and positively, and should deliver gas to the meter at constant low pressure, say three inches of water, under inlet pressures ranging from one pound to fifty pounds gauge.

Reliability under varying conditions of pressure at the inlet is the first essential, otherwise the regulator fails of its purpose.

QUESTION: What is the best method of testing pipe and fittings for a distributing system which is to operate a maximum of fifteen pounds?

ANSWER: The questioner does not state the character of pipe and fittings or conditions to which his question applies. This would plainly have an important bearing upon the method of testing.

Generally speaking, compressed air is the quickest, cheapest and most satisfactory test.

In entirely new installations the compressor ultimately intended for the gas distribution can be used on air, and the pipe laying begun at the works.

A pressure is then maintained on the mains the entire time the work is in progress and is controlled by valves at suitable intervals. It is generally conceded that high-pressure systems should be equipped with valves at all crosses, or at least so placed that comparatively small districts may be cut out.

If valves are not used, or the districts are very large, the above method is rendered impracticable. Neither can it be applied in the case of main extensions.

Under the valve system, when mains must be extended, the testing can usually be done quite satisfactorily with gas by

simply raising the street pressure by means of the compressor so as to insure a reasonable safety factor. The governors will take care of the temporary increase in pressure, so that the consumers along the line will not be affected.

Where the conditions are such as to render it impossible to obtain the necessary pressure, either air or gas, from the works, a small gas-engine air-compressor outfit mounted on a wagon may be employed, similar in every respect to that used by the compressed-air cleaning companies or the sand blast concerns now familiar to all of us.

A portable outfit of this sort is simple to operate and not expensive. The pipe and fittings can then be made up in lengths to suit the conditions and subjected to test before going into the trench.

A system to be operated under a maximum of fifteen pounds should be made tight with very little trouble. By the use of proper material in the first place, by a careful inspection of same, particularly the threads, before making up, and by the exercise of care and intelligence in the laying, the leakage specter will disappear.

In general, the best method of testing pipe and fittings is that which most nearly approaches the conditions under which they are to be used.

GENERATING AND DISTRIBUTING SYSTEM OF THE PORTLAND GENERAL ELECTRIC COMPANY.

(Continued from page 308.)

each, to operate the three-phase circuits, a separate circuit being provided for each machine, practically as they are today, thus making each machine at Oregon City each three-phase circuit, and each rotary converter at Portland one seperate unit.

When Station B was built it was decided to change the frequency from 125 to 33 cycles in order that arc and incandescent lamps might be operated from the same frequency as that used in operating the rotary converters. Sixty cycle rotary converters at that time were not successful, and it was hoped that low frequency arc lamps would be developed, hence the compromise frequency adopted.

With this brief history regarding the reasons for developing the transmission line as it was and is at present, and for adopting a frequency of thirty-three cycles, I will proceed with a short description of the generating and distributing system.

The Portland General Electric Company furnishes power for lighting the cities of Portland, Oregon City, St. Johns and suburbs, and for operating the railways of the Portland Consolidated Railway Company and the Oregon Water Power & Railway Company, and also for operating the Portland Flouring Mills and for other manufacturing purposes near at hand. The generated current is three-phase thirty-three-cycles, 10,000 volts, and can be furnished either from the water power plant at Oregon City, known as Station B, or from the steam station, located in Portland, known as Station E. This power is led to the sub-station in Portland, known as Sub-station H and located at the corner of Seventh and Alder streets, where part of it is changed by means of static transformers from 10,000 to 2300 volts, to be used for lighting purposes. It is distributed throughout the city of Portland at this voltage, and at a frequency of thirty-three-cycles, over single-phase circuits. The rest of the current for lighting purposes is transformed by means of motor-generator frequency changing sets from three-phase thirty-three-cycles 10,000 volts to three-phase sixty-cycle 2300-volt current, which in turn is distributed throughout the city by means of single-phase circuits.

The street arc lighting is accomplished at the present time by Thurston-Houston direct current open arcs furnished with current from the original Excelsior arc machines, which are operated by means of individual "D62" Thomson-Houston motors, direct driven from the 500-volt direct current railway machines.

Power is furnished to the railway system from Oregon City, and is conducted by means of individual transmission circuits to five 400-kilowatt rotary converters, and one 1000-kilowatt rotary converter, located at Sub-station A. This power is furnished to the Portland Consolidated Railway Company at a pressure of 550 volts at the bus-bars, the railway company providing the necessary feeders, etc., for distributing it to its trolley wires. The power or flour mill circuit at the present time is operated at about 6000 volts, over a three-phase thirty-three-cycle circuit. It is intended, however, to change this in the near future, to operate at 10,000 volts.

The various stations operated at present by the Portland General Electric Company are designated and located as follows:

Station B, located on the west bank of the Willamette Falls, at Oregon City.

Station C, formerly known as the Union Power House, located at the corner of Sherlock avenue and Twenty-first street, Portland.

Station D, which is located at the corner of Mill and Chapman streets, Portland.

Station E, which is the new steam plant, located close beside Station C.

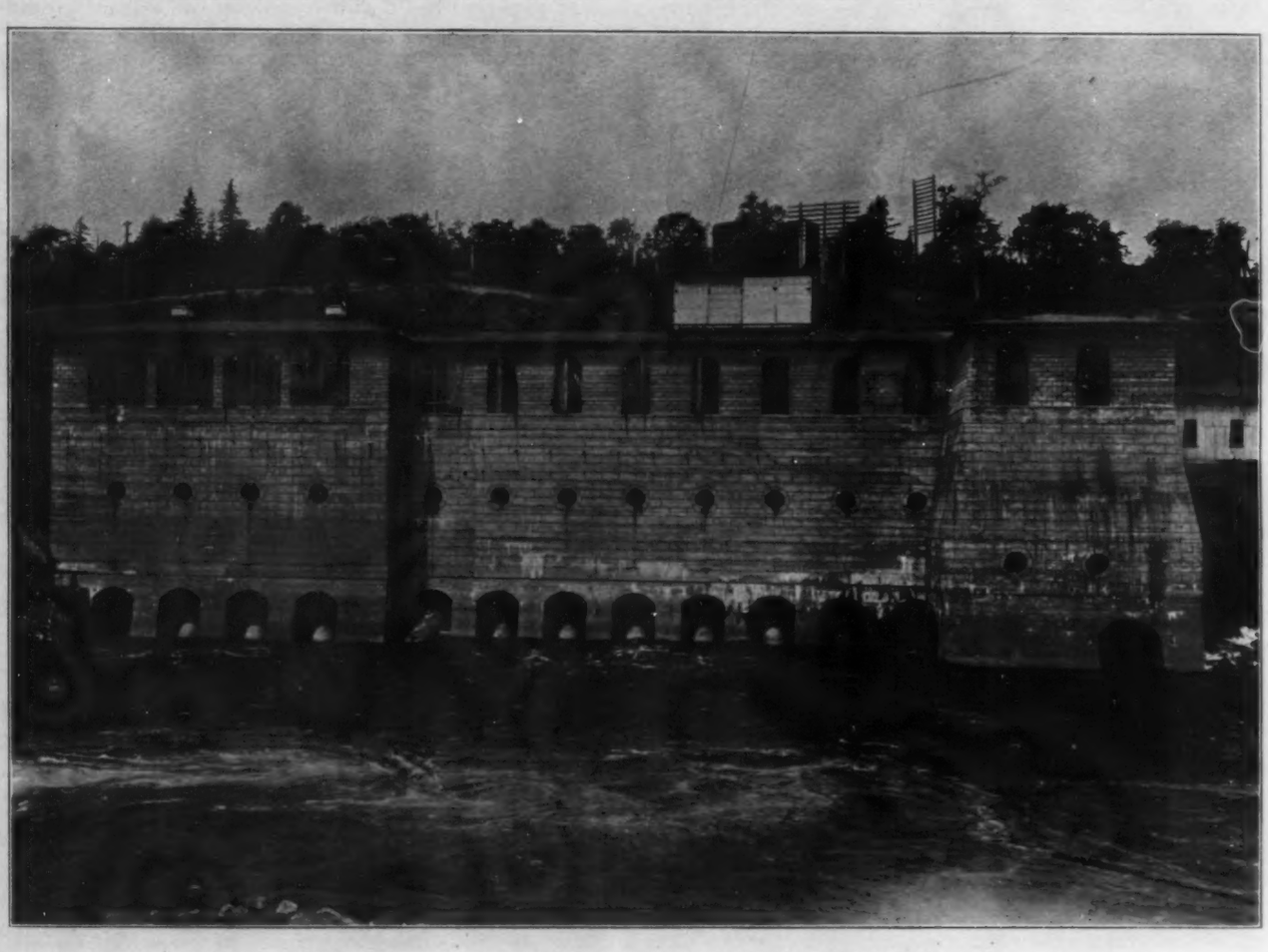
Sub-station A, which is the distributing transmission station, and is located at the corner of Seventh and Alder streets.

I will now take up a description of each of these stations in turn.

The first five sections of Station B, with the foundations for seven additional sections and the bulkhead immediately above were built in the fall and winter of 1893-4; the seven additional sections were completed and foundations for the last two sections were built during the fall and winter of 1896-7, the last two sections being completed early in 1903. This building is of concrete construction and consists of a series of pier walls, vertical and horizontal arches, connected and reinforced by the use of iron rods built in the concrete, and arranged to form separate chambers or independent sections below the generator room for the draft tubes flume and water-wheel rooms. The first set of arches above the foundations forms the floors of the flume and wheel rooms, and the second set of like arches forms the roof over the

flume and wheel rooms, and the floor of the generator room, which is of cement.

The generator room is 246 feet long, 206 feet of which is thirty-eight feet wide and forty feet is sixty-four feet wide. Its concrete walls are seventeen inches thick and twenty feet high from floor to roof truss plates, and are strengthened with pilasters every sixteen feet; the room is well lighted and ventilated by twenty-six windows six feet two inches by thirteen feet three inches. The roof is of timber truss, plank sheathed construction, covered with composition felt gravel roofing, and having wire tower of like construction near central part.



STATION B OF THE PORTLAND GENERAL ELECTRIC COMPANY, AT OREGON CITY, OR.

Station B is equipped with a twelve-ton electric traveling crane, and two twelve-ton handpower traveling cranes. The electric power crane can be used throughout the entire length of the building except in the end offsets, which are served by the handpower cranes. The switchboard and electric controlling apparatus is located in the central portion of the building below the wire tower. The racks to prevent debris getting to the wheels are set at inclination of one and one-half inches per foot to facilitate cleaning, and are supported by a steel frame of "I" and channel beams securely tied together and built into the concrete walls of the station. The forebay or headrace is open and extends along in front of and up to the concrete wall of the station.

The tail race is a natural arm of the river extending to and into which the station is built. The penstocks are of wrought steel, having cast iron heads and covers, and are connected to the open forebay by short steel cylindrical feed pipes extending through the concrete wall of the power station. Each unit is an independent and equipped with a supply gate operated by handpower through gearing. The supply gate is provided with large balanced iron wickets, so that it may be closed and the water shut off from the penstock without difficulty, even though the wheel gates could not be closed nor the wheels shut down through accident to their particular gate gearing or from other cause.

The original overflow dam is a timber crib plank deck, rock filled dam, fitted and secured to bedrock with iron anchor bolts, and has an upstream slope of two horizontal to one vertical, and a down-stream slope of one horizontal to one vertical. The slopes converge to an apex formed of heavy timber, rounded off. The height of the dam varies from three to twenty feet, and its greatest width of base is thirty feet.

The original dam structure, located on the west side of the river and extending to the center of the falls, was built in 1889 and was still in good condition after having

passed, without serious injury, through the greatest floods known, when it was replaced last year by a solid concrete dam, made necessary by new works constructed at the falls. The present length of overflow dam is 2460 feet.

The power station proper, with its bulkhead and open forebay or headrace, occupies about 54,000 square feet. The storage area directly above and in front of the wheels, considering the open forebay only, is 27,500 square feet, and it has a depth of twenty feet at low water.

The water supply of the Willamette River above the falls is furnished and maintained by the watershed immediately tributary to itself and tributaries, among the most important of which are its coast and middle forks, the McKenzie, Calapooia, Santiam, Pudding, Mololla, Long Tom, Mary's, Luckiamute, La Creole, Yamhill and Tualatin Rivers, with their numerous forks and smaller branches, having their sources in the Calapooia Mountains at the extreme headwaters of the Willamette itself, and the Cascade and Coast Range Mountains, respectively; the whole system draining an area estimated at, approximately, 10,000 square miles.

The water conditions at this station are somewhat peculiar, owing to the fact that the normal head varies at different periods of the year from approximately forty feet to approximately twenty feet. During the months of May and June, the snows melting from the mountains at the headwaters of the Columbia and Snake Rivers, makes the former back into the Willamette. While the height of the river above the falls does not vary greatly, that below the falls, during these seasons of the year, is very much increased, thus cutting off the head. For this reason it was necessary to install two separate turbines, one forty-two inches in diameter and the other sixty inches in diameter, as noted below. During the months of July, August, September and part of October, the head is very high but the quantity of water is at its lowest stage. Throughout the rest of the year there is no lack of either water or head.

STATION E OF THE PORTLAND GENERAL ELECTRIC COMPANY, AT PORTLAND, OR.

The water wheels are the regular American "Mixed Flow" turbine type, set above the tail water, and using draft tubes of twenty-one feet vertical distance between the wheels and the surface of the tail race at low water, in the sections equipped with vertical settings, and twenty-seven feet vertical distance between the center of the wheel shaft and the surface of the tail race, at low water, in the sections equipped with horizontal settings.

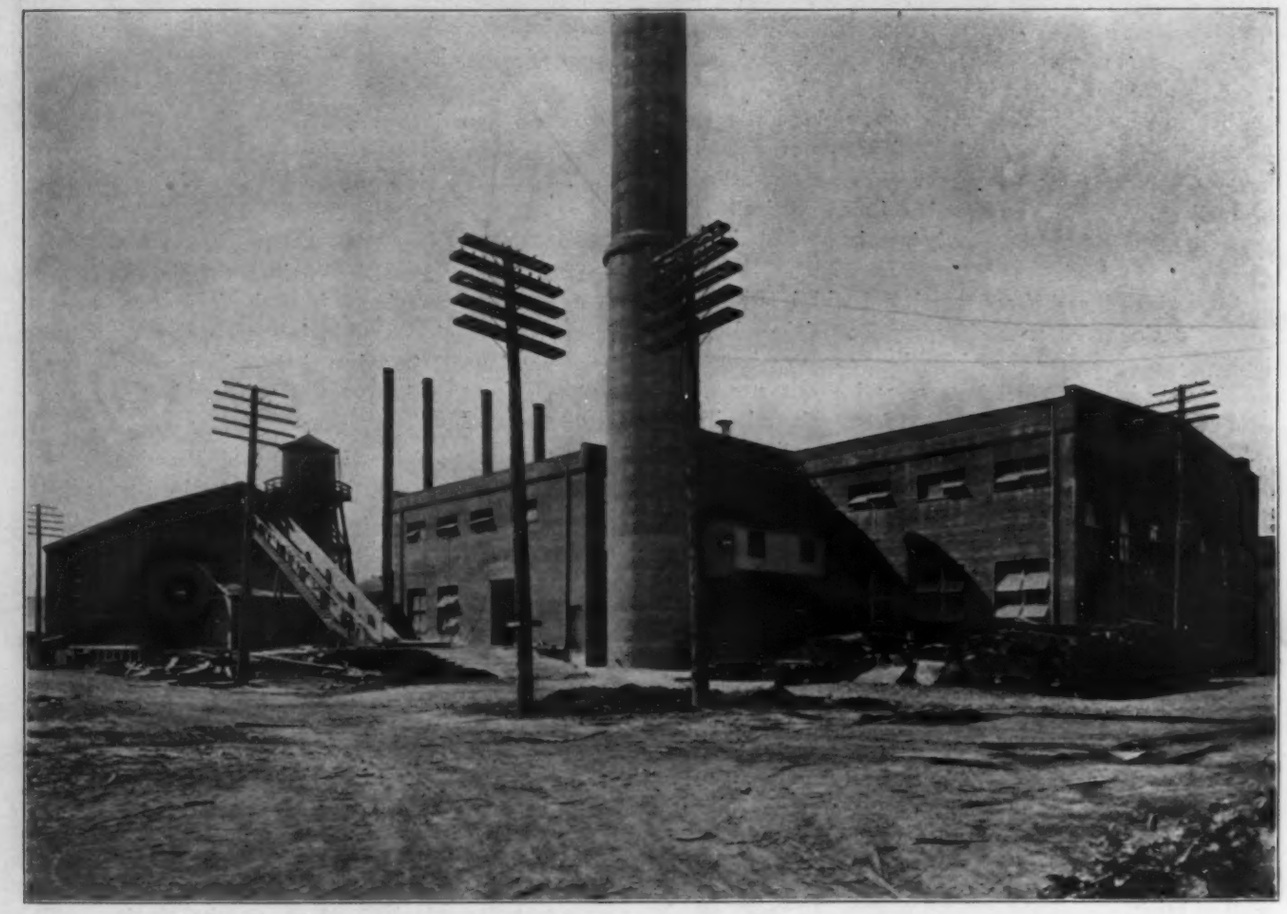
The main water-wheel equipment consists of ten Victor cylinder gate wheels forty-two inches in diameter, and ten increased capacity Victor cylinder gate wheels sixty inches in diameter, each set on

vertical shafts. One wheel of each of the above diameters is installed in each section as one setting and is arranged to drive a single generator at a fixed speed, 200 r. p. m. at all heads varying from twenty to forty feet. These units are arranged so that they can be operated separately or all together for driving the generator, as may be required to get the best results and the most economical use of the water. The generator is direct connected to the forty-two inch wheel shafts and the sixty-inch wheel is connected to the forty-two-inch shaft and generator by means of an endless horizontally running double leather belt forty-six inches wide. The tension on this belt is controlled by a belt tightener that is arranged to move on its track by pinion and rack gearing, and the tightener shaft is supported on an ample step and runs in trunnion self-adjusting bearings, all of which are provided with self-lubricating oil baths.

In addition to the above equipment, there are installed two standard Victor cylinder gate wheels, each 15 inches in diameter and set on horizontal shafts. These sets are used in the pump section for driving the oil and water circulating pumps. There are also provided two Victor cylinder gate wheels forty-two inches in diameter, each of which is placed in its own vertical shaft, the two wheels, however, being located in one section and arranged to be used, at the present time for furnishing power to the electric railroads around Oregon City.

The latest additions to the station are two horizontal sets, each consisting of two new McCormick cyclinder gate wheels fifty-one inches in diameter. direct connected on the same shaft to a 540-kilowatt general electric generator.

All the vertical wheel shafts mentioned above are provided with ring thrust and oil pressure piston bearings, except the sixty-inch wheel shafts, which have only the ring thrust bearings. These bearings are placed in cases, supported from the flume heads on cast iron columns, and are arranged to carry the weight of the generator, armature or field, as the case may be, and of the pulleys and shafts. No part of these weights come upon the water wheel steps, as the shafts are separated by the coupling above the water wheel and the connection is made with a heavy pin drive or jaw, as the case may be, the faces of the separate halves of the coupling being one-quarter of an inch apart.



REAR VIEW OF STATIONS C AND E OF THE PORTLAND GENERAL ELECTRIC COMPANY, AT PORTLAND, OR.

The generators installed in this station are of the following types and capacities:

Seven 450-kilowatt, three-phase 10,000-volt, revolving armature, thirty-three-cycle generators.

Three 500-kilowatt three-phase 10,000-volt, revolving field, thirty-three-cycle generators.

Two 540-kilowatt three-phase 10,000-volt, revolving field, thirty-three-cycle generators.

One section contains:

Two 200-kilowatt, vertical, 500-volt direct connected generators, used either as exciters or street railway generators.

The 540-kilowatt generators are horizontal and the remainder are vertical. To each of the two horizontal generators is belted an eighty-five-kilowatt 125-volt exciter. All of the generators are of general electric make.

The switchboard at Station B consists of general electric apparatus: Form K, 10,000-volt, single-phase oil switches, mounted in concrete compartments, and hand-operated from the control panel. Cambric insulating cables connect the generators with the switchboard. The feeder circuits run from the switchboard up into a wire tower located on the roof of the station, and pass out directly across the canal to the pole line leading to Portland.

The apparatus located in Station D, which is part of the old cable power house formerly belonging to the Portland Railway Company, consists principally of a 325-kilowatt 550-volt direct current railway generator, belted to a small engine. This station has been practically shut down, as power furnished by it is only used at times of extreme heavy load.

As Stations C and E are together, I will describe them as one station. These stations are located in adjoining buildings, on property owned by the company, situated at the intersection of Nicolai street and Front street, the ground area being 320 feet by 200 feet. There is, in addition, a detached strip forty feet wide extending into the Willamette River as far as the harbor line.

Station E is a brick structure with a steel truss roof covered with tar and gravel roofing. The engine room if forty-six feet by 160 feet in size, and is separated from the boiler room by a twenty-four-inch curtain wall. The boiler room is sixty-one feet by 148 feet, with an ell at one end thirty-six feet by seventy-one feet. The curtain wall is provided with fireproof doors, and there are also fireproof doors in the wall between Stations C and E. Station C is composed of a boiler room 100 feet by forty feet, an da nengine room 100 feet by 120 feet, all being in a frame structure with galvanized iron siding, wooden truss roof and tar and gravel covering; the engine room is separated from the boiler room by a twelve-inch curtain wall of brick.

The stack of Station E is 230 feet high, of concrete steel construction, and is twelve feet inside diameter. Each battery of boilers in Station C is equipped with an individual steel stack about sixty feet high by three feet in diameter. Station E is equipped with five batteries of Cahall water tube boilers, manufactured by the Aultman Taylor Co., each battery having a rating of 1040 boiler horsepower, and is built to operate at 175 pounds pressure. Three of these batteries are equipped with Foster superheaters, built to superseat the steam to 175 degrees Fah.

Station C has fourteen 100-horsepower horizontal tubular boilers and four 125-horsepower horizontal boilers, which operate at 100 pounds pressure.

In Station E one end of the boiler room has been reserved for a pump pit, in which are installed three Worthington horizontal centrifugal turbine pumps, driven by vertical engines, and which are used for pumping the condenser cooling water from the river through the condensers. Two lines of thirty-three-inch cast iron pipe are run to the river for this purpose, one being for the suction and the other for the discharge. In addition to these pumps three Blake outside-pack plunger pumps are provided for feeding the boilers. The suctions of these pumps can be taken either from the discharge of the circulating water as it comes from the condenser, or directly from the river. Arrangements have been made so that in case either of these two sources of supply should fail, the water can be forced into the boilers from the city main. The plant is also provided with three Goubert feedwater heaters.

All of the steam piping was furnished by M. W. Kellogg & Co., and installed partly by the Willamette Iron & Steel Co. and partly by the Portland General Electric Company. The high-pressure steam piping, which is made extra heavy, is of lap welded mild open-hearth steel, with Vanstone joints. All low-pressure piping, except the free exhaust from the engines outside of the relief valves and the free exhaust from the feedwater heater are of standard weight wrought iron pipe, the free exhaust above mentioned being riveted sheet iron pipe. The piping is arranged so that any part of the plant can be isolated when desired.

The boilers at Station E are arranged so that they can either burn oil or sawdust, and are provided with Dutch ovens, there being two ovens under each boiler, or four ovens per battery. Each oven is provided with two Morrissey oil burners, and the steam and oil piping, so arranged, by means of unions that the burners can be quickly and easily disconnected when it is desired to use sawdust. An underground storage tank is provided outside of the station, of sufficient capacity to hold two and one-half carloads of oil. This oil is pumped to the burners by means of a pressure pump, built by the Portland Machinery Company.

The main fuel used in the station, however, is sawdust obtained from the Eastern and Western Lumber Co. and the North Pacific Lumber Co. which are located close to the station. This sawdust is transported to the station by team and dumped into a hopper. From this hopper it is carried to the fuel house by means of a conveyer. There other conveyers take the sawdust and carry it to the boilers at either Station C or E as desired, where it is fed into the top of the Dutch ovens. A remarkably hot fire is thus furnished at a low cost.

The generating aquipment of Station E consists of:

Two 1400-horsepower marine type vertical compound engines, built by the Willamette Iron & Steel Works, of Portland. Each of these engines is direct connected to a 1000-kilowatt thirty-three-cycle three-phase general electric alternator.

One Ideal engine exciter of eighty-five-kilowatt capacity.

One motor-generator exciter of sixty-kilowatt capacity.

Two Curtis steam turbines, each rated at 1500-kilowatt, but good for 2000-kilowatt continuously.

The condenser system of Station E consists of two Worthington surface condensers, each having 2300 square feet cooling surface, and two Worthington surface condensers having 7800 square feet cooling surface, the latter being used for the Curtis turbines. These condensers are provided with air coolers and hot wells, and with the necessary dry vacuum and hot well pumps. The turbines are also provided with two outside packed plunger pumps for forcing the water into the step bearing at a pressure of 450 pounds per square inch. An accumulator is also used in connection with these pumps.

The oiling system for the engines consists of White Star oil filter, and for the turbines of two tanks, one placed near the roof and the other in the basement, the oil being pumped into the tank near the roof by means of small plunger pumps and allowed to run through the turbine bearings by gravity.

The piping arrangements are such that water from the condenser hot well can be used for the end step bearings of the turbines, the surplus water not used for these being fed through the heaters back to the boilers.

The generating equipment of Station C consists of:

One double wheelock engine of 1600 horsepower capacity, at 100 pounds pressure, connected with rope drive to one 800-kilowatt 550-volt generator.

One Allis cross-compound engine of 1000 horsepower capacity, connected by rope drive to one 750-kilowatt 10,000-volt thirty-three-cycle alternator.

One 400-kilowatt and one 200-kilowatt general electric street railway generator sets, built to furnish 550 volts, and each direct connected to Fulton engines.

A VIEW OF THE BOILER ROOM OF STATION E OF THE PORTLAND GENERAL ELECTRIC COMPANY

In Station C the Wheelock engine and the vertical railway sets operate non-condensing, while the cross-compound Allis engine, running the 750-kilowatt machine, is provided with a jet condenser.

The switchboard in Station E is composed of general electric apparatus, bus-bars, oil switch mechanism, lightning-arresters, potential transformers, etc., all placed in concrete compartments, and controlled by panels, placed at a suitable distance in front of these compartments. The remote control is used on all high-tension switches. All generators are connnected to the switchboards by means of cambric insulated cobles, drawn into ducts under

the floor. The feeder wires leave the building through pipes and run out underground.

The switchboard equipment of Station C is composed of:

Panels to control direct current 500-volt machines and 750-kilowatt alternator.

Skeleton board at 2300 volts, which controls the current supplied to the Lewis & Clark Centennial Exposition.

The lighting of the station is so arranged that the light can be furnished either from the 500-volt direct current railway current or the sixty-cycle alternating current. Station E is equipped with a twenty-ton hand operated traveling crane, with a hoist arranged to operate electrically.

The maximum horsepower of the engines and boilers and the kilowatt capacity of the generators at Station E is as follows:

Boilers, 10,400 engine horsepower; engines, 2900 horsepower; turbines, 4326 horsepower; generators, 5145 kilowatts.

The capacity of Station C is as follows:

Boilers, 3200 engine horsepower; engines, 3440 horsepower; generators, 2150 kilowatts.

The one 400-wattmeter vertical set with Fulton engine and the 200-kilowatt similar set are supplied with steam from the boilers located at Station E.

The sub-station, together with the office, is built upon a plot of land located at the corner of Seventh and Alder streets, 100 feet by 100 feet. The building is a one-story brick structure, divided into two parts. The part next to Seventh street is sixty feet by 100 feet, and contains the rotary converters and motor generator sets; that next to Sixth street contains the arc machines in the basement, with the general offices located above. The substation is provided with a twenty-ton hand-operated traveling crane.

The rotary converter equipment of the substation consists of:

Five 400-kilowatt 550-volt and one 1000 kilowatt 550-volt rotary converters, all made by the General Electric Company. An additional 1000-kilowatt rotary converter is now on order, and is expected to be installed during the coming month. These rotaries are each provided with three suitable air-blast transformers, stepping down from 10,000 volts to 375 volts, and each has an alternating current panel and corresponding direct current panel at the switchboard.

The motor generator or frequency changing equipment of the sub-station consists of two 500-kilowatt and one 1000-kilowatt 10,000-volt thirty-three-cycle synchronous motors, direct connected to 2300-volt sixty-cycle generators, each provided with a 125-volt fifty-kilowatt, and sixty-kilowatt in the case of the 1000-kilowatt motor-generator set, combined starter and exciter, mounted on the end of the same shaft.

The switchboard equipment of these machines consists of the motor generator and exciter panels necessary for their control. The thirty-three-cycle lighting equipment of the sub-station consists of six 375-kilowatt 10,000 to 2200-volt thirty-three cycle single-phase transformers, each furnished with its own distributing panel.

The arc light equipment of the sub-station at the present time consists of eight motor generator arc sets, each made up of a 100-light Excelsior arc machine, direct connected to a D-62 motor.

DISTRIBUTING SYSTEM.

The wires of the distributing system are all placed overhead, throughout the city, on poles varying in length from sixty feet in the business area to forty and forty-five feet throughout the residence districts. There are a few lines of fifty-foot poles running into the residence districts, and all the high-tension circuits are carried out from the sub-station on seventy-foot poles.

The crossarms are made of 4x6 inch fir, and are of varying lengths. On the newly constructed or reconstructed lines, they are six feet for four pin, and eight and one-half feet for six pin, with pins spaced fifteen inches apart, and thirty inches between pole pins. On old lines the arms are five feet for four pin, seven feet for six pin, and with pins spaced twelve inches apart, and twenty-four inches between pole pins. On one or two heavy load from the sub-station, the arms are eight pin, nine feet long, with pins spaced twelve inches apart and twenty-six inches between pole pins.

The pins are of three-quarter-inch iron, twelve inches in length, with thread of lead, moulded on one end to receive the insulator. A deep groove, double petticoat glass insulator is used throughout, with the exception of the high-tension lines.

For the residence and business lighting the city is divided into areas, each being fed by a separate 2300-volt feeder which is distributed to pole transformers at various points, and stepped down to 117 and 234-volts on the three-wire system, at which voltage it is distributed to customers.

The lighting is accomplished on one phase of the three-phase system, and all houses whose installations consists of twelve lights or over are required to be arranged to use a three-wire wattmeter.

The tranformer units vary in size from one to thirty-kilowatts, the larger sizes being used throughout the down-town and heavy load districts, while the smaller sizes are used throughout the residence districts. The total transformer capacity connected to the distributing system is about 4600 kilowatts.

The high-tension line between Oregon City and Portland, about fifteen miles in length, is constructed for the most part on forty-five and fifty-foot poles, placed partly on a private right of way, but mostly on the county road. Through the city of Portland it is run on sixty and seventy-foot poles.

The cross arms throughout are a special four-pin arm 4x6 inches by nine feet long, with pins spaced twenty-four inches apart and forty-eight inches between pole pins. The insulators used throughout are a special triple petticoat glass insulator, made by the Locke Insulator Manufactur-

ing Company, having a diameter of six inches and height of five inches, and are placed on three-quarter-inch iron pins, with a length above the cross arm of seven inches. A private telephone line and 500 volt call-bell system is carried on a separate arm, placed five feet below the lowest high-tension cross arm.

As stated earlier in this paper, each rotary converter is at the present time an independent unit. The lighting side of the transmission line has recently been rebuilt, the separate wires being twisted together, and there are now simply three conductors, all of the lighting generators being run in multiple.

The high-tension line between Sub-station A and Station E, is two miles in length, and is constructed for one-third the distance upon seventy-foot poles, and for the remaining distance upon sixty-foot poles. It consists of two 10,000-volt circuits, the wires of which are strung on two cross arms and spaced thirty inches apart. The insulators are the same as those mentioned above as being in use on the high-tension Oregon City line.

Most of the power installations at the present time are of 500-volt direct current connected to the railway system, but as rapidly as possible it is intended to change these motors for those using three-phase sixty-cycle alternating current, a third wire being run out into the suburbs where necessary for this purpose. Where the amount of power used is extensive, as in the manufacturing district, a power feeder will be run. The motors at the present time connected to the system amount to approximately 5400 horsepower.

Considerable work has been laid out for the future, and orders have already been placed for a 1000-kilowatt motor-generator set, in addition to the 1000-kilowatt rotary converter already mentioned as being on order. Arrangements are also made for the installation at Station B and Sub-Station A of bus-bars, including General Electric type "H" switches, marble panels, bus-bar compartments, etc. The railway side of the Oregon City transmission line will also be rebuilt.

A contract has been signed between the Oregon Water Power and Railway Co. and the Portland General Electric Company whereby the latter is to take part of the power generated at the new Cazadero powerhouse, beginning on September first, 1906. In order to accomplish this it will be necessary to build another sub-station to be located near the Golf Club, and a duplicate 10,000-volt feeder will be run from this sub-station to Sub-station A. It is intended to have all stations, including that at Cazadero, run in multiple, the power generated being 10,000-volt, thirty-three-cycle, three-phase, it being changed to direct current for railway purposes by means of rotary converters, to sixty-cycle alternating current for lighting and power purposes, and to suitable current for use in direct current series arc lamps, by means of either rectifiers or synchronous motor brush arc sets.

ENGINEERING DATA OF THE SYSTEM OF THE PORTLAND GENERAL ELECTRIC COMPANY.

STATION A.

Location—
Oregon City, East Side.

Building—
Wooden, erected 1889.

Hydraulic equipment—
Three thousand horsepower in Victor turbines.

Electrical equipment—
Six 80-kilowatt, 4000-volt, 125-cycle, single-phase Westinghouse.

Alternators—
Two 120-kilowatt, 200-volt, 125-cycle, single-phase, Thomson-Houston alternators.
Eleven 100-lamp, 2000-candle-power, Excelsior arc-light dynamos.

This plant was abandoned as an electric station in 1903 and is now used as a pulp mill of the Crown Paper Company.

STATION B.

Location—
Oregon City, West Side.

Building—
Concrete, with timber truss roof; 5 sections built in 1893–94; 7 sections built in 1896–97; 2 final sections built in 1903. Size, 246 feet long, 206 feet of which is 30 feet wide and 40 feet being 64 feet wide.

Hydraulic Equipment—
Ten 42-inch Victor, cylinder-gate, vertical-shaft turbines, each carrying a 3-phase generator.
Ten 60-inch Victor increased capacity, vertical-shaft turbines, belted to its 42-inch mate.
Two 42-inch Victor, cylinder-gate, vertical shaft turbines, each carrying a direct-current generator.
Two 51-inch McCormick, cylinder-gate, horizontal-shaft turbines, each driving a three-phase generator.
Two 15-inch Victor, cylinder-gate, horizontal-shaft turbines for driving circulating pumps.

Governors: Replogle.

Electrical Equipment—
Seven 450-kilowatt, 3-phase, 10,000-volt, revolving armature, 33-cycle, vertical-shaft, General Electric generators.
Three 500-kilowatt, 3-phase, 10,000-volt, revolving-field, 33-cycle, vertical-shaft, General Electric generators.
Two 540-kilowatt, 3-phase, 10,000-volt, revolving-field, 33-cycle, horizontal-shaft, General Electric generators.
Two 200-kilowatt, 500-volt, vertical-shaft, direct-current, General Electric generators, used either as exciters or railway generators.
Two 85-kilowatt, 125-volt, direct-current, General Electric generators, each belt-driven from a McCormick turbine and used as an exciter.
Switchboards: Standard General Electric types, with hand-operated, Form "K," 10,000-volt, single-pole oil switches.
Station Lighting: From Substation A, at Portland, by 60-cycle, 2300-volt, current reduced to 120 volts.

TRANSMISSION LINE.

Length: Approximately 15 miles.
Voltage: 10,000 3-phase.
Poles: Various; length, 45′ and 50′ in the country and 60′ and 70′ in Portland.
Cross Arms: Special 4-pin arms, 4″x 6″x9′, with pins spaced 24″ and 48″ between pole pins.
Insulators: Locke special triple-petticoat glass; diameter 6″, height 5″.
Pins: ¾″ iron, 7″ above cross-arms.
Circuits: Five power lines, each consisting of 2 No. 4 wires; 1 lighting line, consisting of 6 No. 4 wires in 1 leg and 3 No. 1 wires in 2 legs; 1 flour mill circuit to Albina, running down the east side of the river.

STATION C.

Location—
Corner Sherlock Avenue and Twenty-first Street, Portland.

Building—
Corrugated iron with wooden truss roof. Size, 100′x40′ and engine room 100′x120′.

Boilers—
Fourteen 100-horsepower horizontal tubular; 4, 125-horsepower horizontal tubular. Pressure, 100 pounds per square inch. Fuel, sawmill refuse fired through Dutch ovens.

Generating Equipment—
One 1600-horsepower double Wheelock engine, non-condensing, operating by rope drive 1, 800-kilowatt, 550-volt, General Electric railway generator.
One 1000 horsepower Allis, cross-compound, condensing engine, operating by rope drive 1, 750-kilowatt, 10,000-volt, 33-cycle, General Electric generator.
Two Fulton compound marine-type engines, direct connected, respectively, to a 400-kilowatt and a 200-kilowatt General Electric 550-volt railway generator.

Switchboards—
Panels for the respective generators and skeleton board for controlling the 2300-volt current supplied to the Lewis & Clark Centennial Exposition.

STATION D.

Location—
Site of cable powerhouse of old Portland Railway Company, corner of Mill and Chapman Streets, Portland.

Equipment—
A small steam plant driving a 325-kilowatt, 550-volt, direct-current, General Electric railway generators.
This plant is seldom used.

STATION E.

Location—
Sherlock Avenue and Twenty-first Street, Portland.

Building—
Brick, with steel truss roof. Boiler room, 148′x61′, with ell 36′x71′. Engine room, 160′x46′. Stack, concrete-steel, 230′ high, 12′ inside diameter.

Boilers—
Five batteries of Cahall water-tube boilers, each rated at 1040 horsepower. Pressure, 175 pounds per square inch, superheated to 175° Fahrenheit. Fuel, sawmill refuse fired through Dutch ovens supplemented by Morrissey oil burners.

Generating Equipment—
Two 1400-horsepower, marine type, compound condensing engines, built by the Willamette Iron and Steel Company, each direct connected to a 1000-kilowatt, 10,000-volt, 33-cycle, 125 revolutions per minute, 3-phase, General Electric revolving field generator.
One Ideal, 85-kilowatt, 125-volt engine exciter.
One 60-kilowatt, motor generator exciter set.
Two 1500-kilowott 33-cycle, 10,000-volt, 990 revolutions per minute, Curtis steam turbines, each capable of delivering 2000 kilowatts continuously.
Switchboards, Standard General Electric types.

SUBSTATION A.

Location—
Northeast corner of Seventh and Alder Streets, Portland. Size, 100′x100′.

Transformers—
Fifteen 150-kilowatt, 33-cycle, General Electric air-blast transformers in 5 groups, reducing from 10,000 volts 3-phase △ to 375 volts 3-phase for the 400-kilowatt rotaries.
Three 350-kilowatt General Electric air-blast transformers, reducing as above for the 1000-kilowatt rotary.
Six 375-kilowatt, 33-cycle, General Electric air-blast transformers, reducing from 10,000-volt 3-phase △ to 2200-volts single-phase for lighting.
One 100-kilowatt, 33-cycle, 3-phase, General Electric transformer, reducing from 10,000-volt 3-phase to 220-volt 3-phase △ for the motor-generator set used in starting frequency changers.

Electrical Machinery—
Five 400-kilowatt General Electric rotary converters, delivering 550 volts in railway current.
One 1000-kilowatt General Electric rotary converter, delivering 550 volts in railway current.
Two 500-kilowatt motor-generator sets, used as frequency changers, and each consisting of a 3-phase, 33-cycle, 10,000-volt synchronous motor, driving by direct connection a 60-cycle, 2300-volt, 3-phase generator.
One 1000-kilowatt ditto.
Eleven 60-kilowatt motor-generator sets, each consisting of a D 62, 500-volt, T. H. motor, direct driving a 100-light, 2000-candle-power, 9.6-ampere, Excelsior arc-lighting dynamo. (These will shortly be replaced by Magnetite lamps operated through mercury arc rectifiers.)

Alternating Current Laboratory Testing.

BY GEORGE H. ROWE

PART II—CONTINUED.

TESTS ON SYNCHRONOUS MOTORS.

The following tests on synchronous motors are taken in precisely the same manner as in the corresponding alternator tests:

1. The magnetization curve.
2. The short circuit characteristic and synchronous impedance curve.
3. The open circuit core loss.
4. The short circuit core loss.
5. Friction and windage.
6. Copper loss measurements.
7. Regulation.
8. Ratio of short circuit amperes at full non-inductive load field to full load current.
9. Ratio of impedance volts to full load volts.

STARTING TESTS.

Synchronous motors will not start under load. They must be brought under equilibrium with the generator electromotive force before the load is applied. This may be done by means of a small motor belted or geared to the shaft of the synchronous motor in such a way that it can be disconnected after synchronism has been attained. This small starting motor may be a direct current, a single-phase self-starting motor or an inductive motor whose synchronous speed is somewhat greater than that of the synchronous motor to be started. Synchronous motor-generator sets are commonly started from the direct current side. These methods are especially applicable to the starting of both single-phase and polyphase motors. In the case of polyphased synchronous motors the machine can be brought from rest to synchronism by

applying electromotive force to the armature, the field being open circuited. The polyphased current in the armature produces a rotating field similar to that in an induction motor. This field produces eddy currents in the field cores and field collars or bridges with which a polyphased synchronous motor is usually supplied. The resulting torque is usually sufficient to start from rest with an applied electromotive force considerably less than the full line electromotive force. A compensator or auto-transformer is therefore used in such cases.

In starting a motor in this way a very high electromotive force is induced in the field winding, which acts also as a transformer secondary to the armature as primary. Therefore the starting electromotive force should be as low as possible. It is usual to break the field up into several parts by means of switches whenever this is convenient, in order to avoid excessive strain on the insulation of the field during the starting. The electromotive force induced in the field may be measured by means of a transformer of known ratio of transformation, the low presssure side being connected to the voltmeter.

The following readings may be taken:

Position of Armature.	Min. Volts applied to Armature to Start.	Amp. 1 2 3	Volts Induced in Field	Amp. Field of Gen.	Speed of Generator.	Time to Reach Synchronism.

After the machine is in synchronism and connected with the source of electromotive force, the load may be thrown on by means of a friction clutch, or, if the motor drives a dynamo, by throwing the load on the latter.

PHASE CHARACTERISTICS.

Bring the motor into synchronism with tbe generator. Maintain constant impressed electromotive force of the generator. Its frequency also should be correct and constant throughout the test.

Run the motor with no external mechanical load. Vary the field excitation from a minimum to a maximum value depending on the current produced in the armature. For a few moments the armature will usually stand 200 per cent. of the full load value. The phase characteristic for zero load can therefore usually be run between the limits of zero excitation current, producing maximum lagging current in the armature, to an excitation value producing an equal leading current in the armature. Make the following observations:

Impressed Volts. (Constant.)	Speed and Frequency. (Constant.)	Current in Armature of Motor.	Field of Motor.	Mechanical Load on Motor. K. W.
				¼ load
				½ "
				¾ "
				4/4 "
				5/4 "

Plot curves for each load on the motor, with currents in the armature as ordinates and field excitation or normal induced motor electromotive force as abscissæ. The latter can be obtained from the saturation curve,

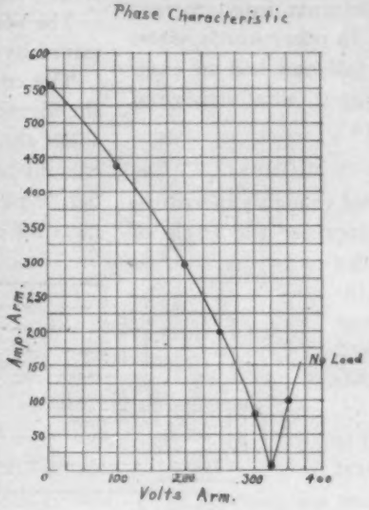


FIGURE 59

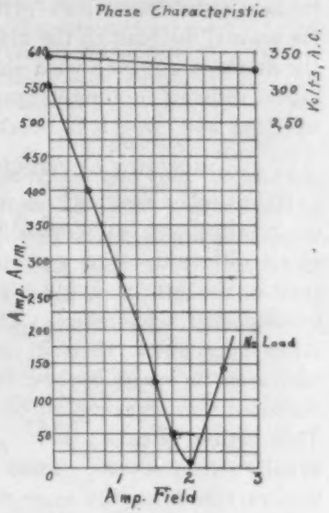


FIGURE 60

knowing the exciting current. Observe also in each of the curves, as plotted above, the points of minimum current in the armature. Connect these points. The resulting curve will be the compounding curve for unit power factor for the various loads. Similar curves can be drawn for other power factors. The above characteristics thus show the excitation required for any load and any power factor. Curves for no load are given in figures 59 and 60.

BREAK-DOWN TEST OF SYNCHRONOUS MOTOR.

A synchronous motor will usually carry a much longer load than its normal rated load before breaking out of synchronism, the rotary being based on temperature rise and efficiency.

The mechanical load on a motor is:

$$W_2 = \frac{E_1 E_2 \cos(\phi - \omega)}{\sqrt{R^2 + L^2\omega^2}} + \frac{E_2 \cos \omega}{\sqrt{R^2 + L^2\omega^2}}$$

This value is greatest when $\cos(\phi - \omega) = -1$, E_1 and E_2 being given.

It E_1 is constant and the motor excitation or E_2 varies, then W_2 is a maximum when

$$\frac{\phi\ \omega_2}{\phi\ E_2} = 0 \text{ or } E_2 = \frac{E_1}{2 \cos \omega}$$

Synchronize the motor, throw on the load, maintaining constant terminal electromotive force by changing the excitation of the generator. Increase the load until the motor breaks down. Then change the motor excitation and therefore the generator excitation to maintain constant terminal voltage and apply increasing loads until the motor again breaks down.

The following readings may be taken:

Volts Armature.	Amp. Arm. 1, 2, 3	Amp. Field of Generator.	Speed.	K. W.	Load.

Plot results with outputs as ordinates and amperes field of motor as abscissæ.

The most important of the above observations will be the determination of the maximum load for the particular field excitation which gives minimum input current for normal full load on the motor. In other words, when the motor is running with normal full load and an excitation causing minimum current input, what accidental overload will cause it to break down?

HUNTING OF SYNCHRONOUS MOTORS.

If the load on the synchronous motor suddenly increases, the rotating part will immediately increase the angle of phase difference. On account of the inertia, the proper angle for the increased load is exceeded. The motor takes more power than it needs and increases in speed beyond the mean position, thus causing an oscillation. This action is called *hunting*. It is usually troublesome when several motors run from the same mains, or when operated from two or more generators connected to engines so as to produce pulsation. The effect can be minimized by short circuiting collars, which have induced in them currents in such a direction as to prevent the deviation from the mean position.

Hunting will be greatest with no load. The pulsating interchange of current causes a pulsating variation of impressed electromotive force due to "line drop." Reactance tends to improve the hunting. Hunting tests are therefore usually made with from 10 to 20 per cent. non-inductive resistance drop in series with the supply circuits.

Make the following observations:

Amperes of Alternating Current Armature.	Amperes Field.	Number of Swings of Ammeter or Pulsations of Lamp.

EFFICIENCY OF SYNCHRONOUS MOTORS.

The efficiency of a synchronous motor is determined in the same manner as in the test on the alternator, except that the core losses are determined for the terminal electromotive force minus the Ir drop instead of plus the Ir drop, as in the case of the alternator.

Plot curves of losses and efficiency as in figure 42.

HEAT TEST.

The heat test is made by running the motor under full rated load and observing the rise in temperature by means of rise in resistance and by thermometer, as in the corresponding test on the alternator.

ROTARIES.

On page 7 of the report of the Committee on Standardization, section 15 will be found recommendations for rotary testing.

The bearing friction, windage and core losses are determined by means of driving motor, as in the preceding tests.

The copper losses are determined in accordance with the formula qI^2r, where I is the direct current in the armature, r is the resistance measured between direct current brushes, and q is a factor depending on the number of phases. (For the various values of q see Steinmetz's Elements, page 235.)

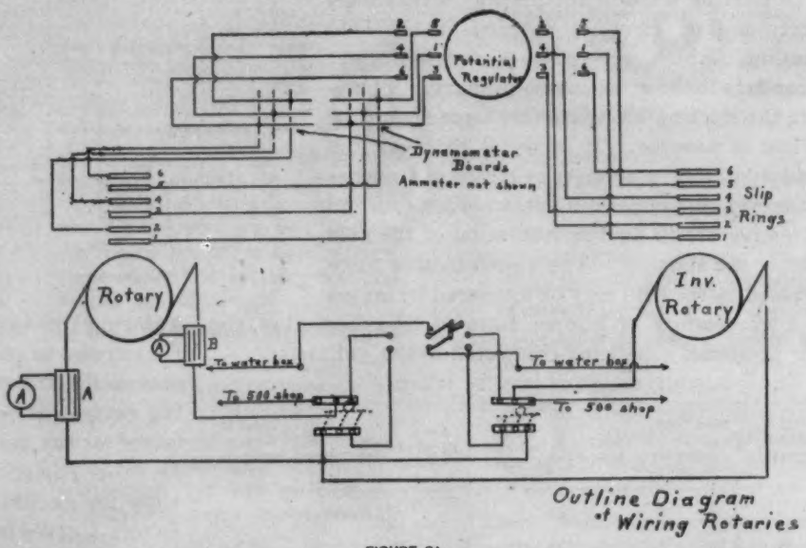


FIGURE 61.

Load losses are determined as in the case of alternators and synchronous motors, as are also losses in the field circuits.

The phase characteristics for various loads are taken as in the case of the synchronous motor. The pumping test, as in the case of synchronous motors, is taken with no load and 10 per cent. line drop in circuit.

The last test is taken with no full rated load on the direct current side and with minimum input current on the alternating side.

When possible it is convenient to test two similar rotaries at the same time, using one as an inverted rotary, the other "pumping back" all energy except the losses into the original source of supply. In figure 61 are shown the connections for "pumping back" two six-phase rotaries, the heat test being thus cheaply and conveniently made as well as the phase characteristics. The connections for the six-phase converter are the double delta—points 1, 3 and 5 being one delta and 2, 4 and 6 the other. The rotary field connections are not shown to avoid complication of the diagram. The potential regulator shown is essentially the rotor and stator of an induction motor, the ratio of which is moved by hand to increase or decrease the alternating current volts applied to the rotary.

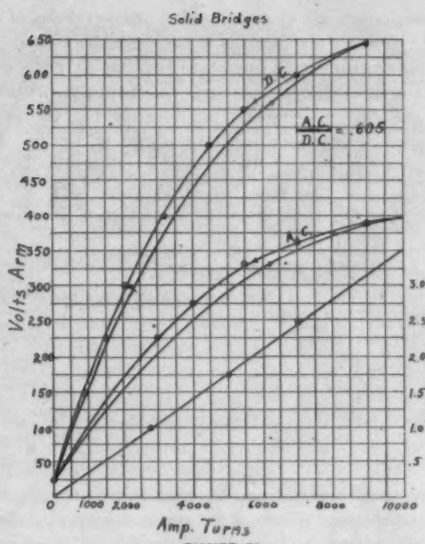


FIGURE 62.

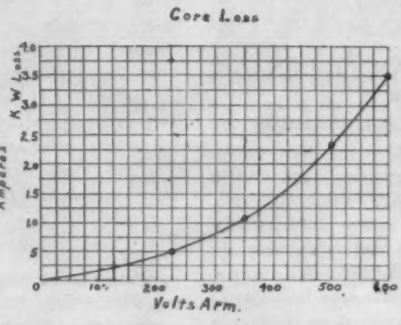


FIGURE 63.

The machine starts and comes to synchronism with the following results:

Minimum starting voltage	38
Minimum starting current	214
Time to reach synchronous speed	59 sec.
Induced voltage on field per spool	362
Core loss (with solid bridges)	——
Iron loss at 550 volts (watts)	2880
Core loss coefficient	2.32

EFFICIENCY.

Assuming 60 per cent. copper loss in armature as direct current generator, to be effective when running as rotary. (See page 235, Steinmetz' Elements.)

One and one-quarter load	94.2 per cent.
Full load	93.5 "
Three-quarters load	92.4 "
One-half load	89.7 "
One-quarter load	82 "

LOSSES.

Full load core loss	298 watts
C^2R armature (effective)	1065 "
C^2R separate excited field	765 "
C^2R rheostat	387 "
C^2R brush contact	341 "
Brush friction	332 "
Bearing friction	1053 "
Full load (total losses)	6903 "
No load (total losses)	5397 "

HEATING.

Rise in temperature after eight hours' run. Run first two hours at 525 volts 182 amperes, direct current. The last six hours at 520 volts and 200 amperes.

	Temperature.
Armature core	31.3
Armature conductors	45
Armature spider	28
Commutator bars	47
Collector ring	24
Pole tip (leading)	22
Pole tip (trailing)	18
Field (by thermometer)	23
Field (by rise in resistance)	36
Room	24
Frame	10

Since a lagging current demagnetizes the field of the inverted rotary, its speed may increase to a dangerous value. The inverted rotary will therefore race and may destroy itself when the current in the alternating side is strongly lagging, or when the field circuit is accidentally opened. Care should therefore be taken to limit the speed of the armature to a value not to exceed 10 per cent. of its normal synchronous speed when running as a rotary.

Since the direct current electromotive force of a rotary is proportional to the maximum value of the alternating wave, and since the voltage of the alternating side is proportional to the virtual value of the wave, the ratio between them will change with the wave form of the induced electromotive force. If the induced electromotive force curve is flat the ratio of direct to alternating will be less than that from a sine wave, and *vice versa*. The ratio should be determined for the machine running as a generator on open circuit. The wave form should also be taken by means of an oscillograph.

Below will be found the important parts of a test on a three-phase, sixty-cycle rotary of six poles, 100 kilowatts, 1200 revolutions per minute and 550 volts:

Direct current volts	550
Direct current amperes	182
Alternating current volts	340
Alternating current	——

The fields are broken in three parts to reduce insulation strain.

DATA DERIVED FROM TEST.

Field ampere turns for 550 volts, no load	5830
Alternating current corresponding thereto	332
Excitation coefficient	1.09
Ratio of alternating current to direct current voltage	605
Total alternating current amperes at normal field, no load	9.5
Total alternating current amperes at zero field, no load	555

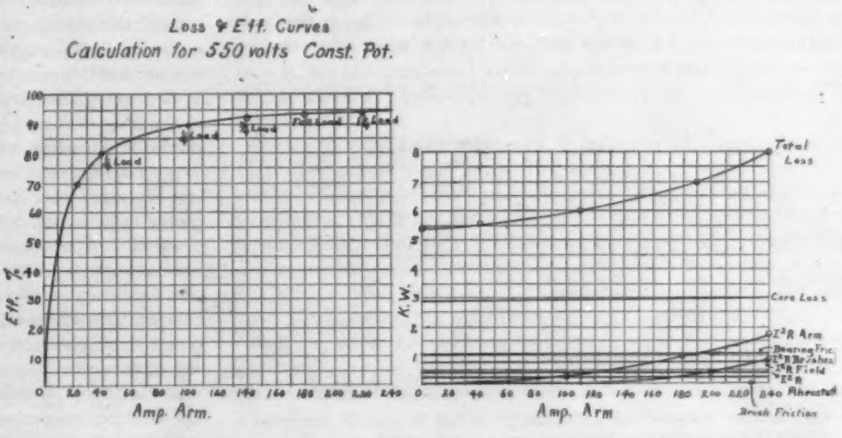


FIGURE 64.

RESISTANCE.	Cold.	Warm.
Armature direct current side	.0477	.0552
Shunt field	153.4	175.8
Brush contact		.0103

Hunting tests were made with 5 per cent. drop in each line, making a 10 per cent. drop between two rotaries.

Magnetization curves, phase characteristics, loss curves and efficiency curves are shown in figures 59-60:62-63-64.

TURBINE PUMPS FOR IRRIGATION AND DRAINAGE*

BY J. J. BROWN, M. AM. SOC. M. E.

THE rapid development and unprecedented prosperity of the United States are based upon agricultural productiveness. To-day we provide for an immense export trade, rendering great masses of people in foreign lands dependent upon our agriculturalists for their daily food. However, if we are to retain this imperial position, it will ultimately be necessary that we have every accessible acre of our agricultural lands under intense cultivation. There are vast areas of land within our boundaries where nature has failed to provide, or has provided in a meager way, some of the essentials of plant life, the introduction of which would rendered the land abundantly productive. In a few cases it is a mineral which is lacking, but in the majority it is moisture. If the latter, as it has been with over 7,500,000 acres of land now brought under cultivation, artificial irrigation is required.

One of the most noteworthy results of irrigation in this country is to be seen in the great rice belt extending from Teche in southwestern Louisiana to westward of Houston, Texas. This immense tract of land comprises in all 610,000 acres under cultivation, a large part of which was practically barren a few years ago. The territory in the Carolinas and the Georgia and Louisiana Basins, which heretofore has supplied our rice, comprises 84,000 acres. A comparison of the two acreages will give an idea of the magnitude of recent developments through irrigation. The capital invested in the rice industry of the Louisiana-Texas belt is estimated at $30,000,000, which includes lands, improvements, implements, pumping plants, mills and canals. The yield in this belt during 1903 netted a sum exceeding $15,000,000 and the great possibilities of this territory have attracted the attention of enterprising Japanese capitalists, who now have several projects under way involving the introduction of Japanese methods on a large scale.

By those who have not investigated the question throughly, the relative expense of developing land by gravity and by pumping systems is usually wrongly estimated. As a matter of fact, even where the cost of power is high, water can often be procured cheaper by pumping than through gravity canals. A compilation of seven instances where water is obtained through canals in Lower California shows that one-sevenths of one miner's inch constant flow per acre of land for six months, making a total of 333,152 United States gallons per acre, or twelve inches of depth of water placed on the land, costs a minimum of $1.00 per year and a maximum of $8.00 per year, the figures being calculated on the basis of 25,000 acres.

Name.	County.	Constant Flow.	Summer Mos.	Charge Per Acre Per Annum	Cost of Water Right Per Acre.
Lake Hemet Water Co.	San Diego	1-8 miner's in.	7	$2.00	$40.00
Sweetwater Dam	San Diego	No restriction	.....	3.50	.....
San Diego River Works	San Diego	1-30 miner's in.	6	3.00	.....
Redlands Water Co.	San Bernardino	1-8 miner's in.	6	1.00	.....
Bear Valley Dam	San Bernardino	1-7 miner's in.	6	1.00	15.00
South Riverside Land and Water Co.	San Bernardino	1-10 miner's in.	6	.....	50.00
Gage Canal	San Bernardino	1-5 miner's in.	6	.....	200.00
Riverside Water Co	San Bernardino	.....	.....	6.00	20.00
Union Anaheim	Orange	1-2 miner's in.	6	8.00	50.00

* An address delivered before the Engineering Section of the Twelfth National Irrigation Congress held at El Paso, Texas.

For purposes of comparison let us assume that one-sevenths of a miner's inch constant flow for six months is the quantity of water required and figure on machinery in duplicate (so that in case of accident one-half of the machinery only will be stopped), which will raise at least 32,000 gallons of water per minute twelve feet high, adding the operating expenses running night and day. A first-class plant will cost $30,000 and the annual expenses, including interest, will be $15,220 per year, or sixty cents per acre, showing a net saving of 40 per cent. over the lowest cost of irrigation by gravity.

Interest per year on $30,000 at 6 per cent	$1,800.00
Chief engineer (salary for whole year)	1,800.00
Second engineer (salary for six months)	600.00
Two firemen (salary for six months)	900.00
Oil, waste, wear and tear	400.00
Coal, 1090 tons at $8.00 for six months	8,720.00
Depreciation in value of plant per year	1,000.00
Total running expenses per year	$15,220.00

Water for irrigation may come from streams, rivers, springs, lakes or wells. The conditions may require large volumes to be pumped long distances, where the head is chiefly due to friction, or the water may be pumped from bored wells or rivers to considerable height above the source of supply.

The supplying of water to rice lands shows the wide field that such problems cover. One tract in Louisiana is supplied by pumps having a capacity of 80,000 gallons per minute, all the water being used on 700 acres, as an immense surplus is needed to supply the loss by seepage through the old levees. These, however will be throughly puddled and water-laid by the ensuing year, when it is estimated that the same supply will cover 10,000 acres. In this case, as in the majority of cases where water is obtained from bayous, the head is very low, the extreme height being thirty-one feet above drainage level. But beyond the reach of canals from the bayous, water is procured from driven wells, which vary in depth from 150 to 250 feet, the water being obtained from a sand and gravel stratum thirty to forty feet in thickness. These wells care for from 150 to 250 acres. Comparing two paying pumping installations located in Louisiana, one plant furnishes water for 150 acres, while a few miles distant there are three plants which have collectively 276 pumps feeding over 800 miles of main canals and watering an area of approximately 560,000 acres.

In parts of Texas, pump irrigation is meeting with marked success. At the plantation of the Natagorda Company, of Bay City, two thirty-six-inch centrifugals were installed three years ago. These pumps deliver 64,000 gallons per minute twelve feet high. The water is drawn from the Colorado River and contains a considerable percentage of sediment and the lift varies with the rise and fall of the river. The pumps are connected by means of rope gearing with a pair of compound condensing engines.

On the Brazos River, the Brazoria River and Irrigation Company has a thirty-six-inch centrifugal, which is located in a masonry pit and delivers 35,000 gallons per minute against a head of forty-eight feet. The engine driving the pump is at the surface and connection is made by means of a rope drive at an angle of about 45 degrees. The suction lift of the pump, including the friction of the long suction pipe, is at low water about twenty-five feet, but no trouble has arisen from this high lift. The pump handles water containing a large percentage of sharp sand. No provision has been made for the protection of the intake since the time the pump was installed, and, as a result, a considerable amount of quicksand from the surrounding hills has been drawn into the suction pipe and a number of landslides have resulted. During the first two weeks after installation the canal was practically filled with sand for a distance of several hundred yards. Enormous quantities have been delivered into the canal, probably amounting to several thousand cubic yards. At times the Brazos River rises twenty feet above the pump and puts such a pressure upon the stuffing boxes that some grit finds its way into the bearings Although the pump has been in use three years no repairs have

been necessary, and an efficiency of about 70 per cent. has been maintained. This company has recently installed a second centrifugal pump which has a suction lift of twelve feet.

Pump irrigation in the Salinas Valley of California has been developed very profitably over a considerable area. At the Spreckels Sugar Plantation 3000 acres are irrigated by means of an eighteen-inch centrifugal pump directly connected to an induction motor. The water is taken from the Salinas River and the total lift averages thirty to fifty feet. Another plantation is owned by the same company, where 500 acres are irrigated by a centrifugal pump. The average cost is $2.00 per acre per year, running twelve hours, the fuel consumption being one-half cord of wood per acre irrigated. At the Soledad Ranch the cost for irrigation by centrifugal pumps is $2.50 per acre. Pumps are used with a capacity of 8000 to 10,000 gallons per minute. The Soledad Land and Water Company irrigates with a belted centrifugal pump working against heads varying from fourteen to thirty-one feet. This plant irrigates 800 acres and cost $10,000 net, including ditching. In the lower Salinas Valley there are many small pumping plants which pump from deep wells by means of centrifugal pumps and gas engines, the crops being alfalfa, potatoes and vegetables. The aggregate area is approximately 2600 acres.

In the Hawaiian Islands irrigation has developed a great deal of land that was arid and unproductive, sugar cane being the most extensive crop. Over 2000 tons of sugar were produced on this land last year, netting the growers $14,000,000. Both gravity and pumping systems are used in the Hawaiian Islands, the latter being necessary in most localities. In the Island of Cahu, which is twelve miles wide and thirty-five miles long, about 300,000,000 gallons of water are pumped each day from wells reaching a stratum 400 to 800 feet below sea level. In other islands the water is taken from pumps excavated five to eight feet below sea level. The pumping plants are usually fed from twelve-inch wells fifty feet apart, each well pumping 1,000,000 gallons, ten operating continually and two being held in reserve. The highest head pumped against is 450 feet. In Waianae a waterfall in the mountains supplies electric power which is used in pumping near the sea level, directly connected pumps being used to lift water fifteen feet. In Maui the pump capacity is 140,000,000 gallons daily; in Kauai, 55,000,000 gallons daily, and in Hawaii, 7,000,000 gallons. The majority of the pumps have been installed for some time and are of the reciprocating type, but the new installations are entirely high-speed centrifugal pumps. In several cases shafts have been sunk 200 to 300 feet to the water level and directly-connected pumps with long vertical shafts reaching to motors at the surface have been installed.

For irrigation from bored wells, the best system is to lower a vertical multi-stage turbine pump into the well, the long vertical shaft being arranged in sections so that the pump may be lowered as the water level recedes. The top of the shaft may be driven by either a vertical-shaft motor or by belt from an oil or steam engine. This system is now in extensive use in Lower California, where the wells are sometimes over 500 feet deep. Horizontal belt drives are now as a rule satisfactory, due to moisture causing the belt to slip and stretch, but when a vertical shaft is employed and the belt arranged wholly above ground, very efficient action may be obtained.

For handling water for irrigating purposes there are two commercial types of pumping machines in general use and to be considered: First, the reciprocating pump, which has been adopted extensively in the past; and, secondly, the centrifugal pump, which is now rapidly replacing it for services like the one under present consideration. Features of construction and operation, such as simplicity, the absence of valves, rubbing surfaces, etc., adapt the centrifugal pump especially to the irrigator's requirements. Reciprocating pumps are well understood, and, in consequence, many companies are prepared to build them. However, any work to which the reciprocating pump is adapted can be done by the centrifugal pump, which is now built for every service and for heads up to 2000 feet. All designs on the market utilize the same mechanical principles, but in the latest improved type superior results are obtained by so designing and constructing the water passages as to obtain a high efficiency at some specified head.

The points to be considered in choosing a type of pump are cost of installation, cost of maintenance and attendance, steam or power economy and the life of the pump. The installation cost may be divided into the cost of the pump, the cost of transportation, the cost of foundations and the cost for erection.

The selling price of the centrifugal pump when compared with that of the reciprocating pump is very low. This is due to the extreme simplicity of construction, the decreased weight and the absence of complicated valve gear, stuffing boxes, etc. The cost for repairs, in case of accident, is also greatly reduced by the simplicity of the parts, and since the troubles which constantly effect the operation of ordinary pumps are entirely done away with accidents are not likely to occur.

In this type of pump the only parts which might be affected by long service are the bearings. These, however, if of proper design, will be long-lived, since the pressure of the impeller or rotating part is uniform and constant. External strains, which necessitate heavy foundations, are entirely done away with by eliminating the reciprocating parts, and, as a result, the expense of excavating for the building of large foundations is avoided and temporary foundations can be used with centrifugal pumps without damage to the machines, loss of efficiency and inconvenience. The cost for moving a centrifugal plant is small, there being no permanent fixtures and the compactness of the machinery renders transportation simple and inexpensive. These pumps require no skilled labor for attendance; in fact, little attention of any kind, beyond caring for the prime mover and supplying oil to the bearings, is required to keep them operating under normal conditions. The lightening of parts and the replacing of reciprocating by rotary parts frees this pump from energy losses due to reversal of motion of the fluid. Its action is noiseless, whether under full or no load.

Space requirements are in many cases of considerable importance, especially if the machine is to be housed in some building or space which has already been provided. By actual comparison, the direct-connected, motor-driven turbine pump occupies one-half the space required by the reciprocating pump driven by a motor and one-fourth that necessary for a direct-acting, steam-driven pump having the same capacity.

The flexibility of the centrifugal pump as regards speed, and, consequently, the method of power supply, is of considerable importance, since it permits the use of directly-connected steam, oil or gas engines or electric motors without the use of power-consuming belts or gears or other transmitting devices.

The centrifugal pump contains only one moving part, viz., the impeller. The remainder of the pump consists of an enclosing core and a chamber for receiving the water from the impeller and conducting it to the outlet pipe. The varying requirements of different services are met by changing the construction and proportions of the several parts.

The centrifugal pumps manufactured by Henry R. Worthington, for instance, are divided into three general types: Conoidal, Volute and Turbine pumps, which meet the requirements of different heads.

In the Conoidal pump the case is widened to admit a special form of impeller, consisting of two blade-bearing cones set base to base in such a manner that all velocity of the incoming water from either side is utilized and the direction of the currents modified without loss of energy. The two entering columns of water are separated by a radial diaphragm extending from the case to the bases of the cones and dividing the pump chamber into two parts, thus preventing impingement and consequent disturbance. Since the water enters from both sides there is no unbalanced thrust transmitted to the shaft. The machines are most efficient for heads up to and including thirty feet and were originally designed for irrigation and drainage work.

The Volute pump derives its name from the peculiar shaping of the discharge chamber, which causes the pump to resemble a

snail's shell. It is adapted for heads up to eighty-five feet. The impeller is enclosed, the blades being so placed between two discs as to permit a maximum chamber opening and to give the least possible resistance to passing liquids. The form of the blades is carefully computed with reference to angles, velocities and cross-sectional areas in much the same manner that a water wheel is designed. These pumps are capable of handling large quantities of floating matter without difficulty and will lift all kinds of liquids effectively. If necessary, they may be constructed of specially hard materials to resist the abrasive action of sand and gravel. They have shown under test that as much as 86 per cent. of the energy applied to the shaft is utilized in lifting water.

High head pumping operations, which are impossible with the ordinary type of centrifugal pump, can be successfully and efficiently accomplished by the use of the Turbine pump. In the design of this pump, the principles of the water turbine were carefully studied with a view to constructing a machine to perform the reverse operation, and the Turbine pump employs the working principles of the turbine water wheel with the direction of the flow reversed, The pump is characterized by a series of diffusion blades, which receive the water thrown from the impeller disc in such manner that energy conversion takes place without loss due to shock and eddies. By arranging several pumps in series on one shaft any desired head may be secured without the necessity of extreme peripheral velocity of moving parts and without introducing complicated systems of outside piping, which greatly reduce the efficiency of any machine. In large sizes, the efficiency of the Turbine pump is above 75 per cent. and any head up to 2000 feet may be overcome.

It may be interesting to note that centrifugal pumps are being used very extensively in processes the reverse of irrigation. In localities where the land is flooded, or the ground saturated through infiltration, rendering cultivation impossible, levees are built enclosing the section to be drained and pumping plants are installed. The usual system is to locate the plant permanently on piles or on ground higher than that to be drained, and by ditching the land radially bring the water to a central canal, from which it is drawn by the pumps. One method of installation, where islands are to be drained, is to mount the pump on a floating scow, together with a steam or oil engine, and then use a flexible connecting pipe of sufficient length to reach any part of the land, floating the scow around the outside of the dike. However, this arrangement is applicable in a comparatively small number of cases. The cost of draining the land in this way depends, as it does in irrigation, greatly upon local surroundings.

Reclamation is being carried out on a large scale along the San Joaquin and Sacramento Rivers in California, which have very little fall for the first 200 miles of their courses. Levees have been built and large pumping plants of thirty-four-inch to forty-eight-inch belted centrifugal pumps having a capacity of from 10,000 to 40,000 gallons per minute have been installed in a number of places.

About 2,000,000 acres of the land in Louisiana jutting out into the Gulf of Mexico and forming the Mississippi Delta were covered a short time ago by cypress swamp. This land is rich alluvial soil of sedimentary origin and northern investors became interested in it, 1,200,000 acres passing into the hands of one concern alone. Reclamation work was carried on by ditching and pumping until it is now fertile and productive. The reclaimed land has an advantage over naturally drained land; for any degree of moisture can be obtained when desired in dry seasons by gates and dams.

To sum up we may say that for irrigation and drainage work the improved centrifugal pump represents:

Cost—
- Initial
- Foundation
- Freight
- Moving
- Erecting
- Attendance

Economy of—
- Power
- Steam
- Fuel
- Space

Freedom from—
- Stuffing boxes
- Rubbing surfaces
- Vibration
- Noise
- Starting load
- Injury by solid matter
- Break-downs
- Repairs
- Requirement for skilled attendance.

Availability for—
- Stationary power
- Portable power
- Steam power
- Gas or oil engines
- Water power
- All services
- All heads
- All situations.

For each separate service special arrangements can be provided for saving expense and labor. Properly selected centrifugal pumps will be found to do their work efficiently and economically. Low efficiency has prevented the general adoption of centrifugal pumps until recently. It is even stated by William Kent in his "Mechanical Engineers' Handbook" that a lift above seventeen feet has not been obtained with a centrifugal pump with any degree of efficiency, although makers have claimed 65 to 70 per cent. for lifts of twelve to eighteen feet. Indeed a recent test on one of the older types of pumps used in an irrigating plant in Louisiana gave a mechanical efficiency of only 30 per cent. In the new type of centrifugal pump careful and scientific design has made it possible to guarantee high efficiency and as high as 86 per cent. has been obtained under test. This very important point should be carefully investigated by the purchaser, as an efficient pump can easily eat up its cost in power in a single season, the more so, since the cost of power in irrigating districts is usually high.

TRADE CATALOGUES WANTED.

THE following self explanatory communication has been received from J. S. Billings, director of the New York Public Library (Astor, Lenox and Tilden foundations.)

TO THE EDITOR—The New York Public Library is paying particular attention to collecting current trade catalogues and similar publications, and I should be glad if you would put before your readers this desire on the part of the library for such literature. Our collection now numbers over 30,000 pieces and, as fast as possible, is being catalogued and shelved in a way to bring out the names of firms or companies issuing the catalogue and the articles listed therein.

We should be glad to secure a satisfactory collection of catalogues of every manufacturer not represented on our shelves today, and to secure from each one of these manufacturers an effective assurance that we shall receive specimens of whatever printed matter he may issue in future. Obviously the value of such a collection cannot be overrated, and obviously its value increases in the number of pieces from individual manufacturers.

"SIGHT SEEING SUGGESTIONS."

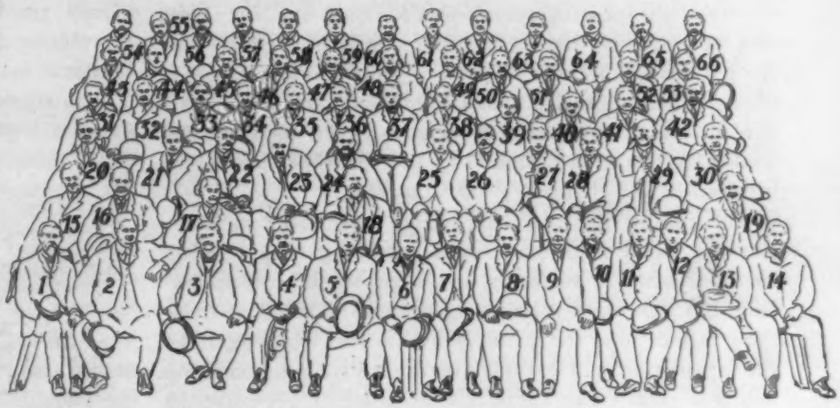
A SMALL coat pocket brochure has just been issued by the Palace Hotel, of this city, under the above title. It is a dainty thing, every page of which is readable, interesting and instructive, and with becoming modesty the only advertising matter it contains is a dozen lines of reference to the court, the lounging room, the empire parlor and a few of the many other features which have been recently added to the Hotel.

Mr. F. E. Fitzpatrick has been promoted from the managership of the San Rafael Gas and Electric Company to the general managership of the Sacramento Electric, Gas and Railway Company vice F. A. Ross, who has resigned.

A GROUP OF ALLIS-CHALMERS COMPANY'S OFFICERS, SALESMEN, HEADS OF DEPARTMENTS, ETC., WHO ATTENDED THE RECENT MEETINGS OF THE COMPANY'S SALESMEN AT MILWAUKEE

THE STAFF OF ALLIS-CHALMERS COMPANY.

The interesting photograph here reproduced was taken recently at the reliance works of the Allis-Chalmers Company in Milwaukee. It is a group of some members of the Allis-Chalmers sales force, as well as some of the officers and heads of departments. By referring to the following numbered list, corresponding to the numbers shown in the picture, the names of all the gentlemen portrayed may be ascertained.



1 James Tribe; 2 G. C. Forgeot; 3 A. Niedermeyer; 4 W. J. Sando, manager pumping engine department; 5 W. H. Whiteside, general manager of sales; 6 W. J. Chalmers vice-president and treasurer; 7 B. H. Warren, president; 8 A. M. Mattice, chief engineer; 9 Arthur Warren, manager of publicity, 10 B. A. Behrend, chief engineer of electrical department; 11 C. C. Tyler, general superintendent; 12 W. M. S. Miller; 13 Ervin Dryer; 14 F. F. Coleman: 15 James Ashworth; 16 H. A. Allen; 17 W. W. Nichols, vice-president and secretary; 18 J. F. Harrison, manager flour mill machinery department; 19 Almon Emerie, superintendent Milwaukee works; 20 W. G. Starkweather; 21 J. R. Jeffrey; 22 C. J. Printz; 23 H. S. Mitchell; 24 I. L. Skeith; 25 G. C. Henry; 26 Robert Mulford; 27 J. C. Buckbee; 28 H. Woodland, assistant treasurer; 29 Clemens Herschel, manager hydraulic turbine department; 30 C. A. Burns; 31 H. L. Wells; 32 Franklin Wharton; 33 H. V. Croll; 34 G. L. Tifft; 35 J. D. Millar; 36 W. C. Trout; 37 M. C. Miller; 38 W. A. Wood; 39 H. Schifflin; 40 J. A. Milne, comptroller; 41 H. S. Pell; 42 G. S. De Wine; 43 H. J. Holden; 44 M. J. Furlong; 45 George T. Thomas; 46 W. E. Dodds, superintendent of construction; 47 Richard Hoppin; 48 H. C. Helvey; 49 Albert Hoppin; 50 A. J. Gates, superintendent Chicago works No. 1; 51 George L. Fisher; 52 W. N. Tanner; 53 Richard Barnard; 54 F. W. Greenleaf; 55 H. S. Mallalieu; 56 H. I. Keen; 57 J. O. Watkins; 58 R. J. Glendenning; 59 G. F. Collins; 60 R. D. Tomlinson; 61 C. A. Derby; 62 G. A. Berg; 63 J. C. M. Lucas; 64 W. O. Everett; 65 H. A. Hammil; 66 D. T. Jones.

The Journal of ELECTRICITY, POWER and GAS
DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

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ADDRESS ALL COMMUNICATIONS AND MAKE ALL REMITTANCES PAYABLE TO THE JOURNAL OF ELECTRICITY PUBLISHING COMPANY

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VOLUME XV AUGUST, 1905 NUMBER 8

EDITORIAL.

HIGH TIME TO ORGANIZE.

Periodically there comes over the electrical fraternity of San Francisco a wave of enthusiasm toward some form of affiliation of a semi-social nature, but with one exception the idea never reached a concrete stage, and even then the meetings which occurred were altogether of an impromptu and informal nature. In fact they consisted merely of a dinner at some down town restaurant, followed by possibly a paper volunteered by some one, or an off hand talk, and a general discussion. That was ten years or so ago, several interesting dinners were held, but the electrical engineering colony was a small one, its interests were at least divergent and in course of a few months the gatherings became no more. Now, however, all is changed, San Francisco has gone beyond any provincialism in the relations which exist between its electrical trades, so that where illiberality once prevailed, all is now broadened into common good fellowship.

The time is ripe, then, for action, and indeed the subject of a social fraternization is receiving consideration by those who are sincerely interested in its consummation, but how shall it be brought about? What shall be the qualifications for its membership and what shall be the means that will not only secure a strong membership but will retain the support that must of necessity be permanently assumed?

Opinions are bound to differ as to the wisest course to pursue. Some hold steadfast to the idea that the club should be of an exclusively electrical membership; others are equally strong in the belief that the membership should consist of electrical and allied interests, while still others—and they are in legion—are convinced that to insure success the lines of the organization must be of the broadest possible character, so long as their scope does not go outside of power engineering and its allied interests. This would embrace mechanical, electrical, civil, hydraulic, gas, mining and other engineering professions, together with all who are identified in the sale and installation of machinery, materials or appliances used by power undertaking, whether they be boilers, engines, pipe lines, water wheels or electrical machinery and supplies, or whether they be managers or contractors employed or otherwise engaged in the construction or operation of power plants or systems in any part. This qualification is certainly broad enough, but it is not too broad if the project is to be organized on a permanent basis. As such, it would become an engineering or a technical club, for instance, rather than one of any specific profession.

The constitution of the club itself—what it shall consist of—is a question equally important with that of the organization of its membership. Its location must be so central that its convenience to the business section of the city shall never be questioned. It should be the recognized headquarters of every engineering society, such, for instance, as the Gas, Transmission and State Miners Associations, the local organization of the American Institute of Electrical Engineers, the Technical Society and the Railway Club, and as such it should have a well appointed assembly hall with a library that will be replete with engineering lore. Its social features must be of exceptional excellence with practically every convenience known to modern club life, yet it can be the club of neither the rich man nor of the poor man exclusively, for the qualification of its membership must be intellectuality. In all probability it should be primarily a day club; it certainly should provide at least luncheon facilities, and above all it should be initiated by those whose names are foremost in the lines of industry which it represents.

It is at least certain that under those conditions the lasting success of the venture will be assured.

THIS SUMMER'S CONVENTIONS.

The Convention season for 1905 for the Pacific Coast has come and gone, all within the brief period of less than a month, and with it have transpired events of signal interest to the engineering world.

Of these Conventions, those of the Pacific Coast Engineering Congress, held in Portland on June 29-30, and of the Pacific Coast Gas Association, held in San Francisco on July 18th, 19th-20th, are of immediate concern to the readers of these columns in that they pertain to engineering subjects alone.

No reference need here be made to the arrangements under which the Engineering Congress were held, nor of the various societies which comprised its organization, as their details have already been made public through THE JOURNAL, nor need space be here devoted to a re-

cital of the events which there occured as they are given elsewhere, but the already excessive size of this number makes it necessary to defer the publication of its papers until the next issue.

The fact that the Engineering Congress was held under the auspices of the Lewis and Clark Centennial Exposition proved an added incentive to an excellent attendance to the former, as its registration was considerably above two hundred. This arrangement was not an unmixed advantage to the Congress, however, for the Exposition proved to be such an irresistable attraction that the Congress virtually became one of its side shows. And in passing let it be said of the Lewis and Clark Exposition that it is one of the daintiest, most exquisite World's Fairs that could be conceived. It is satisfying in its arrangement, its administration, its location, its design, its instructiveness and its entertainments. There is nothing overpowering, nothing overwhelming about it, for one can spend a fortnight there, enjoying every moment, and leave in the satisfaction of knowing that he has seen practically all of its general features without fatigue and with inestimable benefit to himself. If the Portland Exposition is anything at all, it is both comprehensible and satisfying. In these qualifications lie its strength; if it has a weakness it is nowhere in evidence, and long will it live in the memory of expositions as a gem of the purest ray.

Of more immediate concern, however, are the proceedings of the Pacific Coast Gas Association, the papers of which form so prominent a part of this number of THE JOURNAL. These papers are of unusual excellence, and if space permitted it would be a privilege indeed to discuss them specifically. President Lowe's address delivered on retiring as Executive of the Association, discusses in a broad and liberal manner the points of most general interest to gas industries. Indeed, if there is a single condition which towers above all others existing in the gas industry, it is to be found in its comparatively recent evolution from ultra-conservatism to the broad stage of liberality toward the public which it now occupies. President Lowe's address bristles with this new religion of the gas man, but nowhere is it more in evidence than in the pertinent reference made to the suppression of the presidential address of Charles F. Adams, of Portland, whose crime, if it be remembered correctly, consisted in discussing with frankness the reasons why gas companies should always treat the public in a spirit of absolute fairness and honor, fairness in rates and honor in capitalization for instance. It is characteristic of Mr. Adams to have made such an address, for his practice and his preaching always harmonize; it is a reminder of the olden days to recall the fact that of yore the public was under no enlightenment regarding corporate matters, for in some respects they would not bear publicity; and it bespeaks the high character of Mr. Lowe when he says:

"Time the great leveler, has proven to the writer that not only an error was made but a grave injustice was done President Adams [by the suppression of his paper] and it is earnestly recommended that the best possible restitution be now made by publishing the address and making official record thereof."

Among the suggestions contained in Mr. Lowe's address which were acted upon favorably, were several which have a direct bearing upon the affairs of the Association as well as in a degree upon the industry at large. For instance, a committee of three was appointed to actively take up with the officials of the University of California at Berkeley, and the Leland Standford University at Palo Alto, the matter of the adoption of gas engineering courses with the view of giving degrees, or at least of giving courses of lectures on gas engineering during the semesters. The date of holding annual meetings was changed from July to September, and associate membership in the Association was made precedent to a trade display through the novelty department. The library committee was dissolved and the appointment of a librarian together with the secretary and treasurer to be trustee of the library funds with full power of action, was determined upon.

The majority of the board of directors, meeting at any time, were constituted an election committee, ex-officio, with power to elect applicants for membership; a committee was appointed to formulate a plan looking toward the securing of a permanent headquarters for the Association and it was approved that hereafter papers should be printed and distributed to members in advance of the meeting.

John Martin's paper on the "Utilization of Gas Engines in Connection With Long Distance Electric Transmission" created unusual interest because of the fact that it constituted the first authentic announcement that had been made concerning that which is to be the largest and most extraordinary gas engine station in the world. Beyond the presentation of most interesting mechanical data which it presented, the paper can hardly be regarded as an engineering dessertation, rather does it discuss more especially the commercial considerations which have prevailed in the determination to make such an heroic undertaking. The word "heroic" is used advisedly; it has been stated that a single one of these units will constitute a train load of twenty-seven cars!

There seems to be not a shadow of doubt in the minds of those who are immediately concerned in the installation of this remarkable plant but that it will be a success. Indeed no one appears to regard the failure of these engines as being a possibility however remote. Rather are they looked upon as a most remarkable engineering achievement—for success with them is held as of the present and not of the future. They constitute, of course, a noteworthy stride in the developement of internal combustion motors, and as such are a signal epoch in their annals. He would be a zealot who would regard these engines as a *ne plus ultra*. Undoubtedly, will they be looked upon by the engineering world of the present as marvelous; perhaps by that of the future as mastodonic, just as to-day we view with amazement the ponderons

steam engines of the "Great Eastern" and the pumping machinery of the early days of the Comstock. Who knows but that they will afford the key for the solution of that mightiest of power engineering problems so tritely expressed in popular parlance by the statement that 90 per cent. of the energy of fuel goes up the stack?

Does this installation, coupled with the industrial consolidations which have occured during recent years between the gas and electric industries, vouchsafe the truth of the statement long since made in these columns that gas and electricity were sister sciences, that their estrangement was unwarranted, unnatural and suicidal? Does it at last signify the consummation of their union as THE JOURNAL has so steadfastly prophesied?

Mr. Prutzman's paper regarding "Gas Tars" constitutes another of his contributions to the classics of gas engineering literature. Its every line bespeaks the specialist of highest order—indeed the Prutzman papers are to be regarded as naught but enduring stones upon which the permanent structure of gas engineering knowledge is to be reared.

Why Mr. Holberton should submit a paper "On Operation and Construction in the Electrical Department" to an association avowed to gas propensities is incomprehensible except as an evidence of unity of interest. Mr. Holberton's papers are always "topnotchers" and the points he makes are alike invaluable to producer and consumer.

Fred C. Jones' paper on "The Physics and Chemistry of Illuminating Gas" is eminently in the right direction in that it is highly educational in a more or less elementary way. In this connection it is perhaps pertinent to note that there is probably no engineering science which is more vague in the minds of its followers concerning its elementary principles than is gas engineering; gas processes are of prime simplicity when compared with the chemical reactions which underlie them, and to the complexity of the latter may be attributed the lack of general information which exists in their regard. The theme which Mr. Jones has here initiated is one that, if followed up, will redound to the lasting advantage of the industry.

Of the remaining papers several are deserving of special consideration, notably that of Mr. Brown discussing the legal, equitable and economic relations existing between quasi-public corporations and municipalities, and that by Mr. Rix on "The Compression and Transmission of Illuminaiing Gas." Indeed, of all the papers presented before the meeting, that by Mr. Rix will be regarded as most paramount from the standpoint of practical engineering knowledge.

Frank P. Medina announces that he has severed his connection with the Postal Telegraph Cable Company, after eighteen years' association, in order to give undivided attention to his law practice. He has removed his office to room 36, Hobart Building, 532 Market Street, San Francisco, where he continues his general practice in the State and Federal Courts, and his special practice in the field of patents for inventions.

THE PACIFIC COAST ENGINEERING CONGRESS.

ACCORDING to announcements given in THE JOURNAL heretofore, the Pacific Coast Engineering Congress was held in Portland on June 29-30th last, upwards of 200 attendants thereto being enrolled. Three Pullman carloads of engineers with their families constituted the California delegation, while the attendance from Oregon, Washington, Idaho, Montana and from other Eastern states was far beyond expectations. The social features of the Convention were exceptionally fine, including as they did a reception on the evening of June 29th given by President Goode of the Transmission Association at the American Inn to the visiting delegates, excursions to the plant and properties of the Portland General Electric Company at Oregon City, to the Cazadero plant of the Oregon Water Power and Railway Company, to the Locks of the Columbia River at the Cascades, and the excursion features concluding with a trip made by a goodly party to the Puget Sound region, where visits were made to Seattle, Tacoma and to the Snoqualmie Falls. In particular the enduring thanks of the Congress delegates are due to the surpassing courtesies extended by H. W. Goode, retiring president of the Transmission Association, to the Portland General Electric Company through S. G. Reed, secretary, and his fellow co-workers, to Geo. I. Brown, of the Oregon Water Power and Railway Company, and finally, but by no means least, to H. F. Grant, general manager of The Seattle Electric Company.

Owing to the number of papers that had been provided, it became necessary to divide the session into two sections, termed respectively the General Engineering Section and the Electrical Transmission Section. As announced, the Congress was called together in joint session in one of the parlors of the American Inn at 10 a. m., of Thursday, June 29th, by H. W. Goode, president of the Pacific Coast Electric Transmission Association, and a permanent organization was effected by the election of Geo. W. Dickie, of the Technical Society, as president, and Milnor Roberts, of the Pacific Northwest Society as secretary, together with an executive committee consisting of Franklin Riffle, of the Technical Society, Mr. Roberts and Geo. P. Low, of the Transmission Association.

Thereupon an address of welcome was delivered by Mr. Goode, as president of the Lewis and Clark Centennial Exposition, to which responses were made by Charles E. Fowler, on behalf of the Pacific Northwest Society, Mr. Dickie as president of the Technical Society, and Mr. Low as secretary of the Transmission Association.

The business of the Congress was then proceeded with in joint session by the reading and discussion of the following papers:

"The System of the Portland General Electric Company," by F. G. Sykes, General Superintendent Portland General Electric Company.

"The New Power Plant of the Olympia Light and Power Company at Tumwater, Wash.," by Edward W. Cummings, consulting engineer.

After luncheon, separate sessions were held as follows during Thursday afternoon and on Friday morning as follows:

Electric Transmission Section, 2 p. m., Thursday, "Engineering and Commercial Features of the Lewiston-Clarkston System," by Allen E. Ransom, electrical engineer of the Lewiston-Clarkston Company, Clarkston, Wash.

"Latest Development in Single-Phase Motors for Commercial Power Purposes," by W. A. Layman, general manager Wagner Electric Manufacturing Company, St. Louis, Mo.

"The Value of Sawdust as Fuel," by O. B. Caldwell, operating engineer of the Portland General Electric Company.

"Report of the Committee on Resuscitation," by A. G. McAdie, chairman.

"Single-Phase Railways," by M. P. Randolph of the Westinghouse Electric and Manufacturing Company, Seattle, Wash.

"The Electrical Engineering Features of the Exposition," by J. R. Thompson, electrical engineer of the Lewis and Clark Centennial Exposition.

Friday 9:30 a. m.—

"On the Cost of Irrigation by Electrically-Driven Pumps from Transmission Service," by W. W. Wheeler, superintendent of the Northern California Power Company, Redding, Cal.

"The Cedar River Plant of the City of Seattle," by J. D. Ross, assistant engineer, Seattle, Wash.

"Expositions as Engineering Educators," by G. H. Patten, of the General Electric Company, Portland, Or.

"Report of Progress Editor," by F. A. C. Perrine, D. Sc., of New York.

"Wrinkles," by R. W. Van Norden, superintendent of the Central California Electric Company, Sacramento, Cal.

"The Question Box," by C. A. Copeland, consulting mechanical and electrical engineer, Los Angeles, Cal.

General Engineering Session, Thursday 2 p. m.—

"Pacific Coast Industrial Engineering Problems," by George W. Dickie.

"Engineering Progress in the Northwest," by Charles Evan Fowler, past president Pacific Northwest Society of Engineers.

"The Principles Governing the Valuation of Water Works Under Private Ownership," by Arthur L. Adams.

"Subterranean Water as Found in the Valleys of California," by John Richards.

"Water Power as a Factor in Industrial Development," by Charles H. Baker, member Pacific Northwest Society of Engineers.

"The Struggle for Water in the Great Cities of the United States," by Marsden Manson.

Friday, 9:30 a. m.—

"Timber Tests: Methods and Results," by Loren E. Hunt.

"The Design of Tall Chimneys of Reinforced Concrete," by George Cotner Mason, the Contracting-Engineering Company.

"Reinforced Concrete Construction," by L. A. Hicks.

"Control of Hydraulic Mining Debris in California by the Federal Government," by Capt. W. W Harts, corps of engineers, United States Army.

General Session, Friday, 2 p. m.—

"The Improvement of the Columbia River Between the Dalles and Celilo," by Major W. C. Langfitt, corps of engineers, United States Army; Captain Amos A. Fries, corps of engineers, United States Army.

'United States Reclamation Service," by D. C. Henny, consulting engineer.

"The Work of the Reclamation Service in Oregon," by John I. Whistler, district engineer.

"United States Reclamation Investigations in Washington," by T. A. Noble, district engineer.

United States Reclamation Exhibit at the Exposition," by E. T. Perkins, engineer.

PERSONAL.

Mr. William Foster, late of the Vallejo Gas Company, has been appointed manager of the San Rafael Gas and Electric Company.

Mr. A. J. Stevens has been transferred from the management of the Chico Gas and Electric Company to that of the Vallejo Gas Company.

Mr. E. G. Dewald has been appointed manager of the Pacific Coast office of The Platt Iron Works Company, at San Francisco, in deserved recognition of a long period of faithful service which he has rendered to the company named and its predecessor—the Stillwell-Bierce and Smith-Vaile Company, of Dayton, Ohio. The duties of the position were entered into on July 1st, and his elevation places him in charge of the extensive interests of the company throughout the territory west of the Rocky Mountains, not only in the matter of water wheels but in pumps and air compressors as well.

Mr. Dewald has been in the service of his present employers almost from boyhood, and his personal acquaintance with the Pacific Coast dates from the spring of 1900 when he came here from their drafting rooms as traveling salesman and engineer. During this comparatively brief period the products of the concerns referred to were not only introduced to the Pacific Coast, but in its water wheel department alone the installations aggregate in excess of 140,000 horsepower. Prominent among these are to be named the Central California Electric Company, Alto, Calif., 6000 horsepower under a head of 650 feet, the plants of the Pacific Light and Power Company known as the Kern River Company, Borel, Cal., 19,000 horsepower at 270 feet, and the Mentone Power Company, Mentone, Cal., 3000 horsepower at 330 feet; the Mount Whitney Power Company, Visalia, Cal., 3500 horsepower under 355 feet; the Washington Water Power Company, Spokane, Wash., 18,000 horsepower under 68 feet; The Seattle-Tacoma Power Company, Snoqualmie, Wash., 10,000 horsepower under 270 feet; the Tuolumne Electric Company Sonora, Cal., 2400 horsepower under 450 feet; the Shoshone Falls Power Company, Shoshone, Ida., 2400 horsepower under 200 feet; the Truckee River General Electric Company, Floriston, Cal., 3000 horsepower under 115 feet; and the Telluride Power Company, Provo, Utah, 10,000 horsepower under 325 feet, in addition to which contracts have just been taken for two 4000 horsepower units to operate at a speed of 400 revolutions per minute under head of 450 feet for the Eel River Power and Irrigation Company, as well as for the hydraulic equipment of the Cazadero Plant of the Oregon Water Power and Railway Company, of Portland, Or., which is to consist of three 5000 horsepower units, each operating at a speed of 333 revolutions per minute under a head of 125 feet. The capacity of the wheels of these installations aggregates 98,500 horsepower, and in addition thereto some 40,000 horsepower in water wheels have been installed in smaller plants, among which may be named the properties of the Consolidated Canal Company, Mesa, Ariz.; the Holton Power Company, Imperial, Cal.; H. W. Fellows, Goldendale, Wash.; Riverside Power Company, Riverside, Cal.; Stanislaus Milling and Power Company, Sonora, Cal.; Texas Flat Mines, Coarse Gold, Cal.; Northwestern Light and Power Company, North Yakima, Wash.; City of Ellensburg, Ellensburg, Wash.; Oriental Mining Company, Corea; United States Reclamation Service, Salt River, Ariz.; C. A. Johnson, Nez Perce, Idaho; Logan City Corporation, Logan City, Utah; Albany Canal and Water Power Company, Albany, Or.; Olympia Light and Power Company, Olympia, Wash.; Yreka Electric Light Company, Yreka, Cal.; Boston and Great Falls Electric Light and Power Company, Great Falls, Mont.; and the Robinson-Switzer Corporation, Alaska. These smaller installations bring the figures up to the imposing total of practically 140,000 horsepower, which fact bespeaks the influence that the interests which Mr. Dewald represents has been able to exert upon the water power development of the West in the brief period of five years. And in so doing it certifies to an engineering and commercial ability of no mean degree on the part of the subject of this sketch.

TRADE CATALOGUES.

"Storage Batteries for Electric Vehicles" describes and illustrates the "Exide" battery of the Electric Storage Battery Company. In writing ask for Bulletin No. 94.

"Water Wheel Governors for all Conditions" is the title of the new descriptive catalogue just issued by the Replogle Governor Works of Akron, O. It deals only with all-mechanical devices.

"The Lighting of Hotels and Clubs"—a dainty edition de luxe brochure of thirty-two pages, issued by the Holophane Glass Company, New York. It is an excellent treatise on indoor illumination.

"The Carbon Regulator for Automatic Booster Control," being Bulletin No. 93 of the Electrical Storage Battery Company, and descriptive of the latest and exceedingly sensitive type of booster regulator.

The Geo. E. Witt Co., of 504 Mission Street, San Francisco, has secured the Pacific Coast agency for Mullin's duplex automatic oil burner regulators, the 1905 catalogue of which is now ready for distribution.

"An Electrified Railway Shop" (Crocker-Wheeler Bulletin No. 58) describes the use of electric motors in the shops of the Pittsburg and Lake Erie Railroad and the manifold advantages resulting therefrom. Finely illustrated; 32 pages.

"Economy Test of a 500-kilowatt Steam Turbine," being Bulletin No. 2 of the engineering department of H. M. Byllesby & Company, of Chicago. Complete data on the performance of a Curtis steam turbine installed for the Oshkosh (Wis.) Gas Light Company.

The "Overstrom Concentrator" describes in most satisfactory detail the form of table that bears the endorsement of the Allis-Chalmers Company for concentrating ores and recovering values from tailings and slimes. It is of twenty-four pages and is termed Catalogue No. 124.

"Power Transmitting Appliances" is the title of the 312 page Catalogue No. 25 of the Medart Patent Pulley Company, of St. Louis, manufactures of all manner of appliances pertaining to power transmission by means of pulleys and shafting. It is freely illustrated, broad in scope and replete with data.

"Gold Milling in the Black Hills," by Prof. H. O. Hofman, of the Dakota School of Mines. This is a finely illustrated and altogether invaluable paper read before the American Institute of Mining Engineers and reproduced in bulletin form as "Special Publication No. 4000" by the Allis-Chalmers Company.

The "Mercury Arc Rectifier" of the General Electric Company is illustrated and described in its Bulletin No. 4411. This is the rectifier to be used by the Portland (Or.) General Electric Company in rectifing alternating current into direct current for the operation of its new street lighting system wherein magnetite lamps will be used.

"Interurban Railway Construction" is the title of an artistic bulletin just issued by J. G. White & Co., Inc. The bulletin is illustrated with several intersting halftone reproductions of various phases of Interurban Railway work, as executed by the White Company. The reading matter in this bulletin describes the organization and scope of the J. G. White Company and the three associated White Companies—J. G. White & Co. (Ltd.), London, England; Waring-White Building Company, (Ltd.), London, and the Canadian White Company (Ltd.), Montreal. A copy will be sent to anyone writing for same to the home office, J. G. White & Co., 43 Exchange Place, New York.

"Reynolds' High Pressure Gas Governors" are especially designed for use on high pressure artifical gas for individual or house use, and are recommended by experienced gas engineers for their durability, extreme sensitiveness and simplicity. Bulletin No. 102, of the California Engineering and Construction Company, Rialto Building, San Francisco, describes them, gives directions for their setting, and points out their many advantages. They are made in all sizes, being designed to operate under inch pressure ranging from fifty pounds to three inches, and to deliver gas at two inches, but by means of a regulating screw the delivery pressure can be raised by tenths to three inches.

"Van Emon Elevators," one of the finest trade catalogues ever issued from any press in San Francisco, is that just published by the Van Emon Elevator Company, of 52-58 Natoma Street, San Francisco, bearing the imprint of July, 1905. It is descriptive of the various products of the Van Emon elevator works, including all kinds of first-class passenger and freight elevators of electric, hydraulic belt and hand power varieties. The concern well typifies the prominence which San Francisco institutions have reached in the manufacture of special machinery. The catalogue is beautifully illustrated throughout its sixty-two pages and may be accepted as an epitome of best practices in elevator construction.

"Lifting Magnets," a beautifully illustrated bulletin issued by the Electric Controller and Supply Company, of Cleveland, O., and which is intended to cover the general subject of the use of lifting magnets for all classes of material. On the second page is given a partial list of materials which may be handled to advantage by means of lifting magnets, and this list is divided into three classes: The first class covers pig metal, scrap of all kinds and material such as rivets, bolts, etc., which may be handled in bulk. Two sizes of magnets for this class of material are described on pages 3 to 15 of the bulletin, with illustrations showing the magnets as actually used in the stockyard of a large steel casting plant. A particularly novel use of this magnet is described on pages 8 and 9 showing the magnet as used for skull cracker work. The size of magnet for any given case depends on the amount of material to be handled per day. Pages 17 and 21 show some cuts of another type of magnet suitable for handling material having flat surfaces, such as plates, billets, ingots, slabs, etc. Page 16 points out the advantages of lifting magnets over ordinary methods of handling material. On page 22 are shown sketches and methods of wiring from a crane cage to the magnet. This is an important point as there is no doubt that many people have been deterred from the using of lifting magnets on account of the supposed difficulty of taking care of the slack wire necessary to provide for the operation of the crane. On the last page is noted the information which is required in order to furnish a magnet and insure its success. The company has a large number of magnets in successful operation and has had an extended experience with magnets for handling all classes of material. All magnets are given a thorough test of from three to six times the lifting capacity guaranteed on a special machine designed for this purpose.

INDUSTRIAL

TAR EXTRACTION IN SAN FRANCISCO.

ONE of the serious problems confronting the gas engineer consists in the eradication of all extraneous materials from gas, whether held in suspension or otherwise, and among these materials is tar, which is a very important by-product, yet a practically unmitigated evil in the distribution of gas. Hitherto the removal of tar, in so far as the same has been possible, was done through the medium of hydraulic mains, scrubbers, and condensers in the case of coal gas apparatus and seals, scrubbers and condensers in the case of water gas apparatus, which have been found capable of extracting approximately a little over a gallon in the case of coal gas and one-fourth of a gallon in the case of water gas. This average is not reached in oil gas, as very little tar is saved by scrubber or condenser and practically none from the seal, the tar being pitchy in its nature is used practically only for fuel purposes when mixed with lamp black.

It seems practically an impossibility to extract more than this quantity of tar from gas by the use of tubular condensers, with a result that a quantity of tar goes into the holders and thence into the system.

There has recently been installed at the Potrero and the North Beach Gas Works of the San Francisco Gas and Electric Company a form of appliance known as the "Improved P. & A. Tar Extractor," the initials abbreviating the names of its French inventors, Messrs. Palouze and Andouin. This extractor in this instance, is placed on the main inlet of relief holder at a point between it and the condenser and all gas passes through it, during which it extracts therefrom the mechanically suspended tar. In

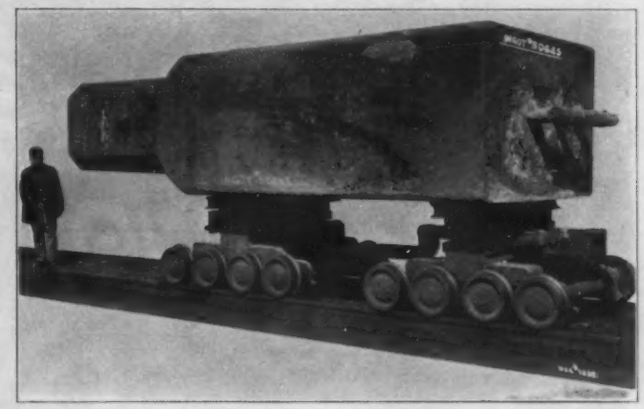
construction it is arranged so that small jets of gas are made to impinge under velocity upon steel sheets through staggered orifices which beat the tar from the gas, whereupon the tar runs down the sheets and collects in the main body of the extractor. The appliance is automatic and the amount of gas to be passed can be regulated by adding or taking off balance weights.

After passing through the tubular condenser the gas reaches the relief holder at a temperature approximately sixty degrees Fahrenheit, which temperature is too low for the ready extraction of tar by any method. The gas passes through the ordinary scrubber and tubular condenser before reaching the P. & A. condenser, the temperature having consequently reached an unsatisfactory point for the extraction of tars, the temperature is again raised by the injection of the steam to a point approximating 115 degrees, under these conditions the extractor removes on an average of one-tenth of a gallon per 1000 cubic feet of gas, making an aggregate of from 500 to 600 gallons of tar they are extracting each day at the Potrero works that heretofore has been passing into the holders, purifiers and the balance of the system.

The P. & A. condenser is manufactured in all sizes varying in capacity from 60,000 to 10,000,000 cubic feet by The Western Gas Construction Company, Fort Wayne, Ind.

A 126-TON CRANK SHAFT INGOT.

EVEN improving figures given in the paper read by Jno. Martin before the Pacific Coast Gas Association* in description of the great gas engine electric station being built by the California Gas and Electric Corporation, in Happy Valley, San Francisco, fail to impress one with the magnitude of



the machinery as forcibly as does the accompanying view of the ingot from which the crank shaft of one of the engines has been made.

This ingot, which was made by the Bethlehem Steel Company, of South Bethlehem, Pa., is of open hearth steel, its weight being 252,000 pounds. Its purpose is for the ninety-degree double throw crank shaft that will be 38 inches in diameter and support a fly wheel weighing 130,000 pounds. As stated in Mr. Martin's paper, these engines will each indicate the 5333 horsepower required to drive the 4000-kilowatt generator with which they are to be direct connected.

A NEW PROCESS IN WELL BORING.

CONSIDERABLE interest is being shown by those connected with gas and oil well drilling in the operations being carried on at Stockton for the Stockton Gas and Electric Company. A twelve inch well is being put down by the rotary process, and it is reported that the well, which was begun a week ago, is already down some 800 feet. The California Hydraulic Engineering and Supply Company, who are the sole agents for the process, state that this is the first machine of the kind used on the coast.

*Beginning on page 312 of this issue of THE JOURNAL.

THE CENTURY ELECTRIC CORPORATION.

THE prosperity which the country has been enjoying for several years past has been fully participated in by practically all of the electrical industries of the Pacific slope, but by none more than the Century Electric Corporation, of San Francisco, which has worked its way well to the forefront of the electrical manufacturing and supply houses of this city. Its new five story building at 28 Second Street is rapidly becoming a headquarters for everything electrical.

Among the appliances which it handles as Pacific Coast Agents should be principally named the Gould storage batteries of the Gould Storage Battery Company, of Depew, N. Y., the Hartman oil switches of the Hartman Circuit Breaker Company, of Dayton, O., the telephone apparatus of the Connecticut Telephone Manufacturing Company, of American, Conn., and, as well, Dougan ammeters and voltmeters.

Of these, the most important installation that it has recently made is that of a series of Gould batteries as an auxiliary to the service of the Portland Consolidated Railway Company, of Portland, Or. Its repair and manufacturing departments are under the direct supervision of L. D. Hitzroth, the well known electrical and mechanical engineer, and its construction department, which is under the able superintendency of H. S. Tittle, is at present probably handling a greater amount of construction work in San Francisco than any other concern. For instance, it holds the contract for the electric wiring of the new Fairmount Hotel, the largest contract of the kind ever awarded in the city, the new Crocker Building, corner of Post Street and Grant Avenue, as well as government contracts for the wiring of the quartermaster's department of the United States Army at Point Bonita, Monterey, Fort Baker, Fort Miley and the Benecia Barracks, not to mention many other smaller contracts, the aggregate of which reaches an imposing total.

"UNOR"—A NEW STEEL.

THE Sheffield Steel Makers, (Ltd.), of Sheffield, Eng., are beginning the production of a new steel known as "Unor" which is remarkable in that it does not resemble any steel which has been made so far by producers of tool steel, and its characteristics mark it as an entirely new class of material. If any comparisons were made, its cutting and wearing capacities would range between that of the good old type of original Mushet self hardening steel and the best of the modern high speed steel. "Unor" steel has the property of air hardening, and in addition to possessing the capacities already mentioned it will serve equally well for the processes of finishing and of roughing. The treatment required to manufacture tools from steel of this description has established a record for simplicity. All that is necessary to harden it is to heat it to a bright red, and not beyond the "critical point," as is the case with current types of high-speed steel, and to allow it to cool naturally in the air without the use of an air blast. The obviation of the use of an air blast simplifies the process greatly. To anneal "Unor" steel for easy machining all that is required is to heat it to a cherry red, let the heat sink over the fire to a very dark red, and then to plunge it in the water. Experiments have proved that it can be rehardened or softened any number of times, and that the wearing quality of this new tool material does not deteriorate in any way in the course of these processes. In tests made with twist drills of "Unor" steel at the Sheffield Testing Works, on a railroad tire made of Cammell's steel of 0.49 per cent. carbon, 49 holes, each 15/32-inch in diameter and 1 7/8 inches deep, were drilled at an average speed of twenty-five seconds each. A 13/16-inch drill, made from this steel, drilled twenty holes, two inches deep, in sixteen and one-half minutes. In both cases the tool used was left in good condition.

Another new product of these Sheffield works is a water-hardening tool steel capable of maintaining a keen cutting edge longer than anything of the kind hitherto produced. Some pocket knives have been shown, the blades of which were made of this material. Externally they differed in no way from the ordinary,

but their peculiarity rested entirely in the quality of the steel employed. The blades were whetted up to carry a razor edge, which was tested by shaving a hair. A large piece of redwood was then brought in and an unmerciful slashing was entered upon with the small blade. Large knots were encountered in the course of the experiment, and everything that could be thought of to test the durability of the blade was done. Had the blade been composed of ordinary steel, a few cuts upon the wood that was used would have brought it to the semblance of the saw. But on re-testing the knife the edge was exactly as at the outset of the experiment, and would have served for shaving.

The steel to all appearence is in itself a paradox. Notwithstanding the fact that it is hard enough to cut glass, it will bend easily. The blade was laid over the edge of an office table, and when hammered with a steel bar, it was bent to an angle of sixty degrees without breaking. After this the blade was broken in half, and the steel would cut glass with the greatest of ease. A great number of tests have been made, revealing the astonishing cutting and staying power of this material. Files which have been made from it have been found to wear four times as long as tools made from other kinds of steel.

THE ELKS CARNIVAL AT BUFFALO.

THE entire business part of Buffalo was in gala attire in honor of the nineteenth reunion of Elks. Bunting of many colors—purple, the Elks color, predominating—was draped everywhere in such profusion as even the glorious Fourth seldom witnesses. But if the daylight scene was gorgeous, it was

far excelled by the electrical decorations which literally turned the night into day.

The unique feature of this veritable festival of light was a "Mercury Arc Tower" located in Shelton Square. This was a fluted column of "staff" seventy-five feet high, studded with 100 mercury arc lamps. Standing alone in its splendor, this tower produced a most startling effect, due largely to the characteristic greenish light of the mercury arc lamps. It stood out conspicuously in the mass of many colored incandescents covering the fronts of the buildings on the Square and its radiating streets. The natural curiosity of the people regarding its peculiar color caused a constant jam about its base. Inasmuch as the tower was visible for a long distance up the streets leading from the Square, it received a great deal of attention and was freely spoken of as the most original feature of the carnival.

The mercury arc lamps were operated in two series of fifty lights each from four ampere Brush arc machines located in the Wilkinson Street station. As each lamp consumes only 160 watts, the operating expense was extremely low for so brilliant a spectacle. They are of the standard type for outdoor lighting as developed under the direction of Dr. Steinmetz, and manufactured by the General Electric Company.

PELTON WHEELS FOR EXPORT.

THE Pelton Water Wheel Company, of San Francisco and New York, has just closed a contract for a water wheel installation for D. J. Aguirre & Co., of Tepic, Mex. The head available is 175 feet, and the plant consists of two Pelton wheel units of 700 horsepower capacity, each direct connected to 300 revolutions per minute General Electric generators, also two Pelton wheel units for driving exciters. Sturgess oil type governors will be used. Pelton wheels are universally employed at the sugar plantation of Aguirre & Co., there being six wheels at present employed for driving heavy sugar rolls by means of direct connection, machine shops, electric lighting, etc. It is worthy of note that the export trade in Pelton wheels has largely increased in the past year, this company having made large shipments to Central and South America, Japan, and the Strait Settlements. Indications for further increase in these directions are most favorable.

THE "DOORENBOS" GAS ARC LAMP.

The Arthur R. Haskins Co., located at 501-5 Howard Street, San Francisco, has been appointed Pacific Coast agent for the Scovel & Martin Manufacturing Company, New York, manufacturer of the well known and efficient "Doorenbos" inside and outside gas arc lamps. The particular features of this type of gas lamp are that they can be adjusted and regulated without removal of globe; they have a mantle wind protector which can be lowered when the globe is removed for cleaning thus protecting the mantles from loss by wind. By lowering the mantle protector one can burn off new mantles without smoking globes, which are bug, weather and wind-proof. The globe can be lowered without breaking the mantle and the lamp is made with four or five burners.

THE BUSCH MANUFACTURING COMPANY.

The Busch Manufacturing Company, of 13 Trinity Street, San Francisco, announces that, having perfected its standard boring machine for electric wiremen, as is evidenced by its general sale throughout the East as well as the West, it is in line to take up the manufacture and marketing of new mechanical and electrical devices, or to engage in experimental work of any description.

JNO. MARTIN & CO., MOVES.

Messrs. Jno. Martin & Co., who are prominent in transmission undertakings through the important agencies they handle, announce that about August 15th they will remove their offices from the second floor of the Crossley Building to its ground floor frontage facing on New Montgomery Street and adjoining the offices of the Stanley-G. I. Electric Manufacturing Company.

THE LOCKE FACTORY GROWS SOME MORE.

In addition to the enlargements announced in these columns as having recently been made to the plant of The Locke Insulator Manufacturing Company at Victor, N. Y., the company has just begun the erection of another factory building, measuring 40 by 100, to be devoted exclusively to cementing together the parts of multi-part porcelain insulators.

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